WATCH CLEANING AND REPAIRING

Edited by
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Editor of "Work."

FULLY ILLUSTRATED

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EDITOR'S PREFACE

"WATCH CLEANING AND REPAIRING" is a companion "Work" Handbook to an earlier volume in the series, namely "Clock Cleaning and Repairing," and is by the same two expert watch and clock repairers—"G" and "Horologist." I have compiled it from articles and from many hundreds of replies contributed by them to the pages of "Work," the Illustrated Weekly Journal of Handcraft, and I believe it will be found extremely practical, remarkably complete for its size, and quite up-to-date. Very great pains have been taken to provide it with a trustworthy index, disclosing at a glance the nature of the information given. I am sure that "Horologist" will be very glad to give further information through the pages of "THE AMATEUR MECHANIC AND WORK" (but not by post) on any matter referred to in this book. Readers should address their queries to me.

B. E. J.

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WATCH CLEANING AND REPAIRING

CHAPTER I

Introduction: Tools and Materials

THE successful watch repairer is the one who can locate little faults with ease and certainty. There is a purely mechanical cause for every vagary, and a search will reveal it. There are no mysteries. Some faults, indeed, are so small that they take a great deal of finding, but they are there to be found all the same.

Whilst practical demonstration counts for much in learning watch cleaning and repairing, it is undoubtedly true that anyone with a good knowledge of practical mechanics or possessed of a keen desire to learn, and whose daily work is not so heavy as to spoil the touch and roughen the hands, may learn how to repair watches and clocks from written instructions.

Tools.—If an amateur intends doing watch cleaning and repairing in earnest, it will be necessary to lay out about from £1 to £2 in tools. Certainly nothing can be done without, at least, an oil pot, tweezers, two pairs of pliers, cutting nippers, pin vice, sliding tongs, a watch hammer, two or three files ("smooth" and "bastard"), two screwdrivers (ordinary and jewel size),

pegs, pith, a watch brush, a small parallel bench vice, and a weak eyeglass (see Figs. 1 to 20).

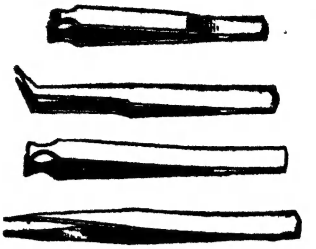
Other useful tools include half a dozen broaches of different sizes, two small screw ferrules, box of punches (these tools can be turned and drilled from rod steel much cheaper than they can be bought), hollow stake, burnisher, pinion drills, and fast-cutting oilstone.

Watch pinion drills, as sold, are too soft for use, and there is difficulty in hardening them because of their small size. An old method is to heat them in a flame and rapidly withdraw them with a sudden jerk. This is called "flirting" them, and the sudden cooling in the air effects the hardening. A drill is worked by a fine gut or hair bow coiled round the pulley, while the centre runs in a hole in a fixed object, such as the vice. These drills are usually left in the rough, and require to be filed to shape and sharpened. This is easily accomplished by fixing the wire in a pin vice, revolving it on a wood block in the vice, and filing the shoulder taper, leaving a large or bull head, which is then filed flat with the edges diamond shape. Different sizes can thus be formed, and they will be found most useful for drilling brass when small holes are required.

Steel burnishers are polished on an emery buff or fine emery on a board, rubbing the burnisher across in the opposite direction to that in which it is used when burnishing. It is then cleaned on a piece of tissue paper, oiled, and worked in an up-and-down motion on the pivot or object to be burnished.

If it is desired to do any turning work, at least a pair of turns will be needed; better still, of course, is

Fig. 1.—Watch Screwdriver



Figs. 2 to 5.—Tweezers

Fig. 10.—Watch Hammer

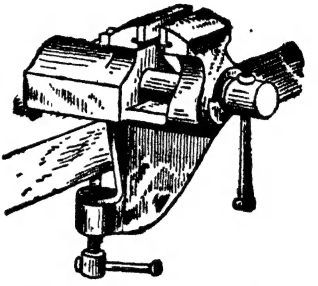


Fig. 7.—Parallel Bench Vice

Fig. 6.—Hand Vice

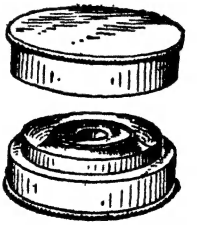


Fig. 9.—Oil Pot or Oil Cup

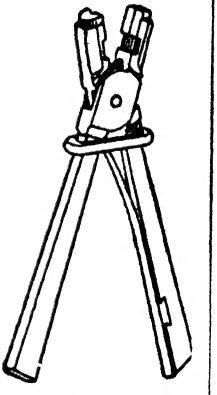


Fig. 11.—Sliding Tongs

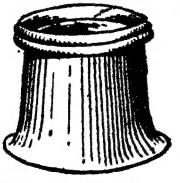


Fig. 8.—Eyeglass

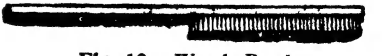


Fig. 12.—Watch Brush

the watch lathe, costing anything from 50s. to £10 or more, according to completeness. Two or three hard gravers will be required for turning.

Materials.—Watch "pegs," already mentioned, are thin round sticks of dog wood, purchased in bundles at the material shop. Pith for cleaning is also obtainable in the same way. The petrol used for cleaning watch parts is the ordinary petrol used for motors.

The lubricating oil should be the best obtainable. "Kelly's" American watch oil is recommended. "Watch oil" is oil especially prepared for watches. and none other should be used. It is sold in small bottles, and is used by placing a drop in an "oil pot" (a small cup with a cover, made for the purpose, as in Fig. 9), and applied by an "oiler" (Fig. 15) (a piece of thin brass or steel wire with a blade hammered thin like a little spade or a drill blade, but thinner, and provided with a handle, which may be of brass or pegwood, or simply sealing-wax). To use the oiler, touch its blade with oil from the oil pot, and apply it to the pivot. Used like this, one drop of oil put in the pot will oil several watches. The oiler is also used to place the oil in the pot. Dip it deeply into the oil bottle, and transfer a complete drop to the pot. Then cork up the bottle carefully again, and keep in the dark. In this way, the oil in the bottle is not disturbed or soiled.

Watch oil is extracted principally from the whale or shark. It passes through many forms of refinement before becoming fine enough for watch work; no substitute is satisfactory.

If the reader hopes to do watch repairing on something more than an amateur scale, he may need

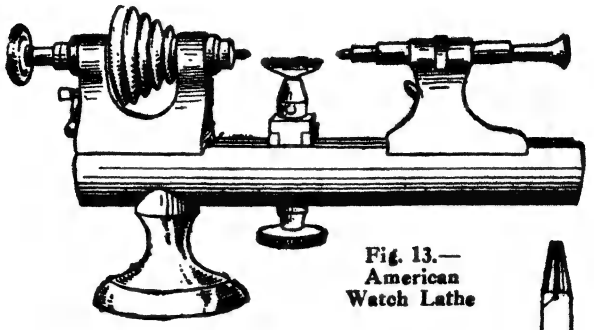


Fig. 13.—American Watch Lathe

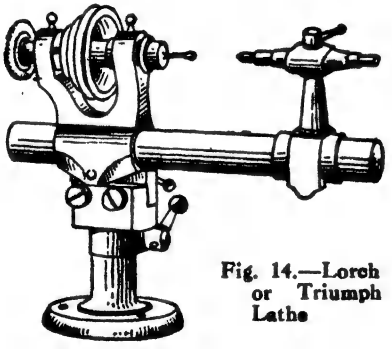


Fig. 14.—Lorch or Triumph Lathe

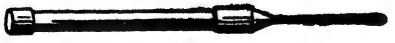


Fig. 15.—Watch Oiler

Fig. 16.—Watch File

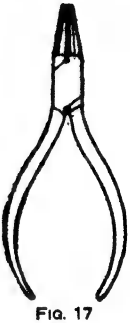


FIG. 17

FIG. 17A

Figs. 17 and 17A.—Round nose and Square-nose Pliers

watch glasses—lunettes in quarters (4 to 24), crystals in eighths (3 to 24), hunters in eighths (2 to 22), in heighths of 6 to 8. Mainsprings, from 1 mm. to 4 mm. in width, sized according to the gauge in use, and in assorted strengths. Keys, 1 to 10. One gross of loose endstones, one gross of set endstones, one gross of set

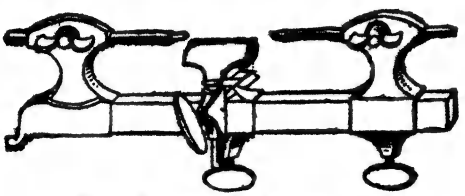


Fig. 18.—English-pattern Turns

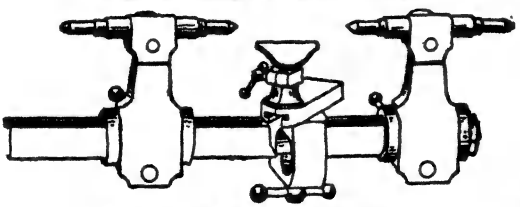


Fig. 19.—Boley-pattern Turns

Fig. 20.—Pin vice

jewel holes, and one gross of unset jewel holes. Two dozen Geneva set-squares. Three dozen each of small clicks and side clicks. Three dozen each of steel Geneva ratchets and brass English ratchets. Half a gross of flatted garnet pins for rollers. Also some bouchons, rough balance staffs, rough hairspring studs and cylinders, one gross of Geneva hairsprings, cards of assorted English and Geneva hands (one dozen pairs on a card), plenty of unfinished screws, and, if possible, a box of " Progress " finished screws.

CHAPTER II

Cleaning American Key-wound Watches

A TYPICAL watch, of which millions are in use throughout the world, is the Waltham full-plate key-wound, now, however, largely superseded by the keyless watch, to which a separate chapter is devoted later in this handbook.

The movements of these watches are held in the case by two "dog-screws" at the edge of the back plate. Having turned these, the movement can be pushed out from the back of the case. Near to the two o'clock there is a small pin in the edge of the movement, which fits into a hole in the case edge and keeps the movement in position. Then the dog-screws hold it firmly when they are tightened. Having taken the movement out, it will be seen to consist of a brass frame containing the barrel and train wheels. On the front of it is the dial, and on the back, held by the balance cock (Fig. 21), is the balance (Fig. 22). Let the raw beginner look at the movement of his own watch, and he will then better appreciate the shape of the balance.

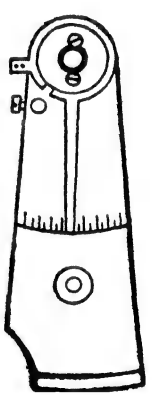


Fig. 21.—Plan of Balance Cock, showing Index

Balance.—The balance, together with its spring

(commonly called the hairspring), is the most important part of the watch, as upon it timekeeping depends. It can be compared with the pendulum of a clock. When set vibrating, or revolving backwards and forwards, under the influence of its hairspring, it will move quite regularly, whether it is turning only a quarter of a turn each way or a turn and a half. As a matter of fact, there is in most watches an extremely small difference between the times of the long and short vibrations, but it can be ignored for the present. The consequence of this equality in time of the vibrations of the balance is that, provided the watch mechanism is in order and capable of keeping the balance vibrating, the watch is sure to keep fair time, but of course the balance and hairspring must themselves be in perfect order. If the balance or spring is faulty, then the best possible mechanism in the rest of the movement will fail to make the watch keep good time.

The essential points of a good balance are as follow: It must be in perfect poise—that is to say, its rim must have no heavy part but be balanced exactly, so that no matter in what position the watch is held the balance will continue to act perfectly. It must have fine and smooth pivots, working in well-fitting and smooth jewel holes, and the ends of the pivots must rest on smooth endstones. The balance itself must revolve quite freely, not being nipped by the presence of the endstones on the pivots, but having just the least trifle of lift or endshake to ensure absolute freedom.

The balance must not touch anything as it revolves, or its freedom of motion will be impaired. For instance, the balance cross-arm sometimes touches the outer coils of the hairspring, and in such a case it cannot possibly keep time. The hairspring must be flat and true in its coils, not "wobbling" as the balance turns; and it must not touch anything.

So the first thing to look at, on taking the watch out of its case, is the balance and hairspring. Give it a spin, and see if it revolves truly. Hold the watch up to the light, and look at the pivots sidewise as the

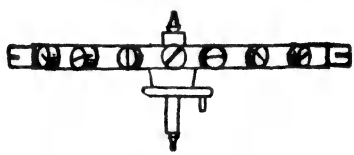


Fig. 22.—Side Elevation of Balance

balance revolves. If they are bent a wobbling will be discernible. Try the endshake with the points of a pair of fine tweezers, lifting the balance rim and letting it fall again to see what lift it has. When doing this, do not look at the rim, as that may bend, and so be deceptive, but watch the roller (a part of the balance staff) or the top pivot. Then the exact amount of lift can be seen. If the balance seems true and free, look at its spring carefully. If that is also free, and seems perfect, the balance cock (Fig. 21) may be removed, together with the attached balance and spring, and passed as in fair order.

Hands.—Turn next to the hands and dial. The minute hand should be firm, and move stiffly when the

hands are set. If it moves easily, it may drag as the watch goes and lag behind, making it appear that the watch loses, whereas the watch may be keeping perfect time all the while. The hour hand should be free —that is, it must have just a little lift, or endshake, under the minute hand, and a little sideplay between the teeth of the hour wheel which carries it. The

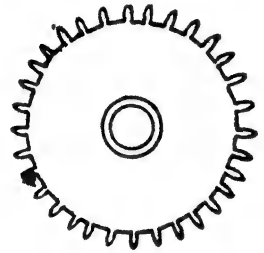


Fig. 23

Fig 24

Figs. 23 and 24.—Hour Wheel

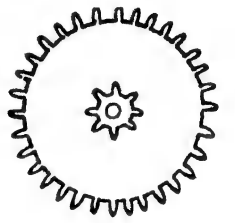


Fig. 25

Fig. 26

Figs. 25 and 26.—Minute Wheel

seconds hand must be quite free and not touch the dial at any point. Sometimes a seconds hand is free in one position and just touches the dial in another, so carefully see it make a complete revolution before passing it as correct. If the hands seem all right, take them off. They can be pulled off by means of cutting nippers.

Dial.—The dial feet pass through holes in the bottom plate of the watch frame or "pillar plate," and are nipped tight by a small screw to each in the edge of the plate. Undo these dial screws a turn or two—

they need not be taken right out—and the dial can be raised by the finger nail and removed. The underside of the movement can then be inspected.

Wheels, etc.—The hour wheel (Figs. 23 and 24) is lifted off, and then the minute wheel (Figs. 25 and 26). The cannon pinion (Fig. 27) is the pinion or small wheel that carries the minute hand on its square, and must be tight on the centre arbor on which it fits, turning stiffly. To remove it, grasp its square by cutting nippers and pull it off with a twisting motion.

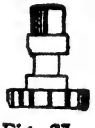


Fig. 27.—Cannon Pinion

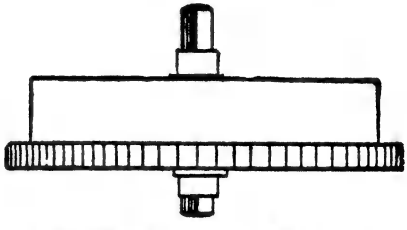


Fig. 28.—Barrel and Mainspring

Attention must next be directed to the barrel and mainspring (Fig. 28). Put a key on the winding square, and see if the watch is wound up or quite run down. If wound up, and it has stopped, it is proof that somewhere in the train wheels there is resistance to motion, which may be dirt between the teeth of the wheels, or dried-up oil or rust on the pivots, causing them to stick in their holes, or a bent tooth in a wheel, or a bent pivot. A search and examination should be made to locate the fault before taking the watch apart. See, by trying each wheel in succession, where the power fails. Then try the endshake and freedom of

each wheel. In this way the fault may be discovered and when the watch is taken apart the particular part may be closely examined. If the mainspring is not quite run down, place the key on the winding square and press the click A (Fig. 29) out of action, and let the spring unwind itself in the barrel gently. Then unscrew the barrel bar (Fig. 30), and, having taken off the cap (Fig. 31) and ratchet B (Fig. 29), the barrel can be lifted out of the frame.

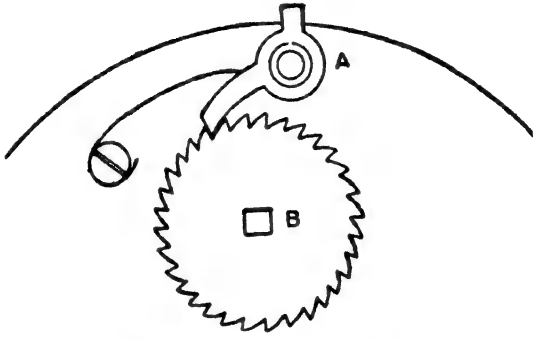


Fig. 29.—Ratchet and Click

The top plate of the frame is held by three pillar screws. These having been removed, raise the plate a little—very gently indeed—and lift out the lever (Figs. 32 and 33). If the plate is simply lifted straight up, the lever will catch, and its bottom pivot will be broken off. So proceed very gently in this operation. The lever being safely out, the plate may be removed and the wheels lifted out.

Roughly dust off the loose dirt and old oil from the wheels and pivots, and, with the eyeglass, examine

them to see if the pivots are straight and smooth, and that there are no bent or broken teeth. Figs. 35 and 36 show the escape wheel, Fig. 37 the fourth or seconds wheel, Fig. 38 the third wheel, and Fig. 34 the centre wheel.

Cleaning Plates and Wheels.—Put the plates and

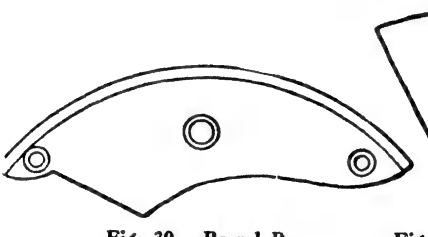


Fig. 30.—Barrel Bar

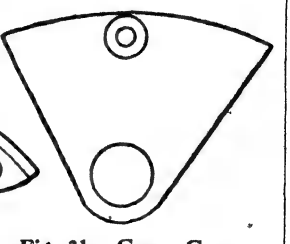


Fig. 31.—Cover Cap

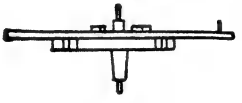


Fig 32

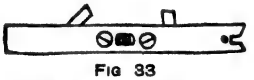


Fig 33

Figs. 32 and 33.—Elevation and Plan of Lever

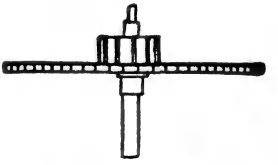


Fig. 34.—Centre Wheel

wheels, leaving out the balance and barrel, into a glass jar with cover, containing a little petrol just enough to cover the parts. Remember that petrol vapour is inflammable; therefore keep the petrol far from any open flame. After a moment's immersion they may be taken out one by one, dabbed dry on a duster, and brushed clean and polished by a soft, dry watch brush

charged with a little chalk dust. Just lightly rubbing the brush on a white billiard chalk will be sufficient. While brushing, the parts should be held in tissue paper to prevent soiling with the fingers. After brushing, sharpen a watch peg to a fine point and "peg" out the pivot holes clean. Repeat this operation until the peg point is not soiled, showing that the holes are quite clean inside.

Fig. 35

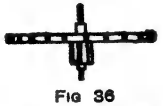


Fig. 36

Figs. 35 and 36.—Waltham Escape Wheel

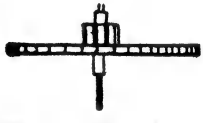


Fig. 37.—Fourth or Seconds Wheel

Fig. 38.—Third Wheel

Cleaning Jewel Hole.— Fig. 39 shows a jewel hole and endstone such as the lower balance pivot runs in. To clean such a hole, it is not sufficient merely to peg it out. The two little "jewel screws" must be removed, and the hole and endpiece pushed out from the inside with a watch peg cut flat. Then the endpiece is rubbed with the finger-tip on a piece of washleather and the jewel hole rubbed and pegged. Both are then replaced. To get the endpiece back

level with the plate, push it in with a flat cut peg. If very tight, cut a peg quite flat and use it as a punch, giving a tap with the watch hammer to force the setting into its place.

Putting together Wheels and Plate.—This part of the watch can then be put together. Hold the pillar plate in tissue paper and place in position the centre wheel, fourth wheel, third wheel, and escape wheel, in the order named. Before putting in the centre wheel oil its lower pivot. Then put on the plate loosely. Take the lever in the tweezers points

Fig. 39.—Jewel Hole and Endstone

and introduce it between the plates until its bottom pivot is in place. Then, with extreme care, apply a little pressure to the top plate, and with the tweezers place the wheels one by one in position, so that the top pivots go into their proper holes in the top plate and the plate drops down into correct position. Screw it on by the pillar screws and the lever, for the purpose of seeing that all are placed in correctly.

Cleaning Barrel and Mainspring.—These parts, for which see Fig. 28 (page 11), can now be taken in hand. The barrel cover or lid is snapped into an undercut groove round the inside top edge of the barrel To get it off, insert a screwdriver blade under the hollow cut at one part of the cover, and prise it off. The steel arbor can be taken out, but the mainspring is best left in The cover and arbor can be cleaned in

petrol in the same manner as the wheels, etc., and brushed dry and clean. The barrel and mainspring may be cleaned by screwing up a small piece of tissue-paper, and wiping out any old dirty oil from the coils and the bottom and inside. The hole is pegged clean. Then fresh oil is applied to the coils of the spring and to the pivots of the barrel arbor. The arbor may be replaced, and the cover snapped on again. In a Waltham watch of the type here dealt with there is only one place or position to place the cover, and that is so that the little notch cut in the barrel cover just coincides with the steel pivot of the mainspring outer end.

Before replacing the barrel in the watch, hold the winding square in a pair of sliding-tongs, and wind up the spring to the top, to make sure all is correct. Let the tongs slowly run back in the hand as the spring unwinds itself, and feel if there is any jerkiness or unevenness in the force. If there is, it is a proof that the coils of the mainspring bind against the barrel bottom or cover, probably because they are bent out of flat, or the spring may be too wide for the depth of the barrel to accommodate.

Presuming that all is correct, the pivots of the arbor that go in the frame plates may be oiled, and the barrel replaced in the frame, the barrel bar screwed on again, the ratchet and click and cover cap put on. A little oil is needed on the flat of the ratchet under the cover cap, and on the pivot on which the click works. Then the watch may be partly wound up and an inspection made. If all is correct, a touch on the

lever will liberate an escape-wheel tooth, and an impulse will be given to the pallets, causing the lever to pass across to the opposite banking pin with a sharp "click."

Cleaning Balance, etc.—Of the going part of the watch, the balance, spring, and balance cock now only remain. Dip the balance and spring quickly into the petrol, and dab them dry very gently, so as not to catch the coils of the hairspring on the bristles of the brush. A good way to brush clean the roller and lower part of the staff is to stick that part through a piece of tissue-paper. It can then be brushed vigorously and quite safely while the tissue covers up and protects the hairspring. The pivots are best cleaned finally with a piece of pith.

The balance cock may be dipped into the petrol and brushed dry and clean, afterwards removing the jewel hole and endstone for cleaning as already described. Re-attach the hairspring stud by inserting it in its hole in the balance cock and tightening its set-screw (see Fig. 21, page 7). In doing so, see that the outer coil of the hairspring passes through the curb pins in the end of the regulator. Before doing this a little oil must be applied to the top balance pivot hole. Now take the movement, and oil the lower balance pivot hole, and the top pivots of the centre, third, fourth, and escape wheels and lever. Then the balance and balance cock can be replaced in the watch and screwed down gently, great care being taken that the pivots are properly in their holes, and that the balance is not nipped tight. It is a good plan to keep the balance just in

petrol in the same manner as the wheels, etc., and brushed dry and clean. The barrel and mainspring may be cleaned by screwing up a small piece of tissue-paper, and wiping out any old dirty oil from the coils and the bottom and inside. The hole is pegged clean. Then fresh oil is applied to the coils of the spring and to the pivots of the barrel arbor. The arbor may be replaced, and the cover snapped on again. In a Waltham watch of the type here dealt with there is only one place or position to place the cover, and that is so that the little notch cut in the barrel cover just coincides with the steel pivot of the mainspring outer end.

Before replacing the barrel in the watch, hold the winding square in a pair of sliding-tongs, and wind up the spring to the top, to make sure all is correct. Let the tongs slowly run back in the hand as the spring unwinds itself, and feel if there is any jerkiness or unevenness in the force. If there is, it is a proof that the coils of the mainspring bind against the barrel bottom or cover, probably because they are bent out of flat, or the spring may be too wide for the depth of the barrel to accommodate.

Presuming that all is correct, the pivots of the arbor that go in the frame plates may be oiled, and the barrel replaced in the frame, the barrel bar screwed on again, the ratchet and click and cover cap put on. A little oil is needed on the flat of the ratchet under the cover cap, and on the pivot on which the click works. Then the watch may be partly wound up and an inspection made. If all is correct, a touch on the

lever will liberate an escape-wheel tooth, and an impulse will be given to the pallets, causing the lever to pass across to the opposite banking pin with a sharp "click."

Cleaning Balance, etc.—Of the going part of the watch, the balance, spring, and balance cock now only remain. Dip the balance and spring quickly into the petrol, and dab them dry very gently, so as not to catch the coils of the hairspring on the bristles of the brush. A good way to brush clean the roller and lower part of the staff is to stick that part through a piece of tissue-paper. It can then be brushed vigorously and quite safely while the tissue covers up and protects the hairspring. The pivots are best cleaned finally with a piece of pith.

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gentle motion while the cock is being screwed down, then if it is nipped or tightened up, a stoppage of the motion will instantly show it before damage is done.

Lever Adjustment.—The watch being partly wound up, if all is correct it should go at once; but, before proceeding farther, look at the lever. Hold the balance half a turn or so round on one side from its position of rest, and see if the lever has a little shake against its banking pin. Then let the balance go and hold it on the other side, and try the lever once more. If the lever is tight against the banking pin on one side the watch will stop; so in such a case turn the banking pin round with a screwdriver (it is eccentric), and give the lever a little more room. There should be just a little shake, but not much.

Completing the Reassembling.—This attended to, oil the lower pivots of the third, fourth, and escape wheels and lever; the centre pivot should have been oiled before putting in place. Push on the cannon pinion, the minute wheel, and the hour wheel, and replace the dial, screwing its feet tight. A little oil should be applied to the escape-wheel teeth. Then put the movement into its case again, and turn the dog screws, not forgetting the rim-cap that goes round the movement to keep out dust.

Finally put on the hands. The hour hand goes on first, and must be free to move a little with the shake of the hour-wheel teeth in the minute pinion. It should also have just a little lift under the dial. If the hour-wheel is nipped it will stop the watch. The seconds-hand pipe must not touch the sides of the hole in the

dial, and the entire length of the hand must be just clear of the dial. The minute hand must push on quite tight and be perfectly firm, and move round rather stiffly when the hands are set.

The hands are not really a part of the watch going-mechanism, but, nevertheless, are a most important part of a watch, and perhaps cause more stoppages than any other. They should never be hastily put on. The seconds hand must be watched all the way round to see that its point or its counterpoise do not touch the dial. The hour hand should be tested to see that it cannot possibly touch the seconds hand as it passes over the latter between five and seven o'clock. And the minute hand must be quite free of the hour-hand point beneath it, and of the glass above it. The centre square also must on no account touch the glass. This can be tested by lightly oiling the top of the square and closing the glass; then open the glass again and examine its surface. If the hour hand has so much play that it rocks about and cannot be prevented from catching either the seconds hand or the minute hand, the hands and dial must be taken off again and paper washers placed over the hour wheel under the dial to decrease the lift and hold it steady. They must still leave just a little play.

The Case.—Before replacing the movement, the case itself will need some attention. It is no use cleaning a watch and putting it back into a dirty case.

Mainspring, lever escapement, balance, pivot, jewel hole, and a variety of other repairs, are treated at length in later chapters.

CHAPTER III

Cleaning Swiss Lever Watches

The Geneva Lever with "Bar" Movement.—There are several distinct kinds of Swiss watches. The cheap full-plate levers resemble Waltham watches in general arrangement, and the directions given in the preceding chapter for cleaning apply equally well. The more typical Geneva lever watches have "bar" movements (Fig. 40), in which most of the wheels are held by separate cocks or bars, or in which at least the top-plate is subdivided. A common type was the three-quarter plate shown by Fig. 40A. Sometimes the barrel and centre wheel are held by one portion and the rest of the train by another, and so on. Watches made on this plan have several distinctive features that will need some description and special directions for taking apart.

Removing Movement.—To take bar watches out of their cases, it is necessary to turn the dog screw that will be found on the pillar-plate. Then the movement will push out from the back. The dials are generally held by two feet, each provided with a screw. This screw should be turned inwards until the hollow in its edge allows the dial foot to be withdrawn. In putting the dial on again the screws are drawn outwards, to

draw up the dial feet tight. If turned inwards they leave the dial feet loose.

Centre Arbor.—Having taken off the hands and dial, and removed the balance, the centre arbor A (Fig. 41) must be removed. This is arranged quite differently from the full-plate watches previously de-

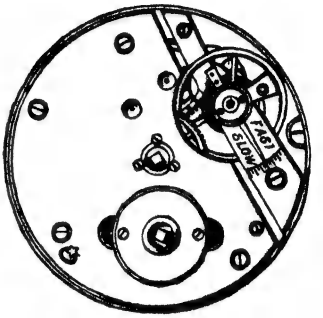

Fig. 40A.—Three-quarter Plate Swiss Watch

Fig. 40A.

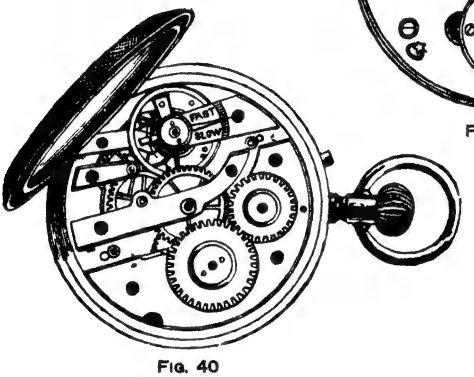

Fig. 40.—Bar Movement Swiss Watch

Fig. 40

scribed. The centre pinion B of a Geneva watch is hollow; that is, it has a hole drilled right through it. The centre arbor carrying the set-hand square passes through this hole friction-tight, so that it can be turned to set the hands. The cannon pinion C is pushed tight on the arbor and does not move. Fig. 41 shows the arrangement. To remove the arbor, hold the movement in the hand, and give a smart tap with a watch hammer

to the projecting end of the arbor where the minute hand fits on. This will drive it through the cannon pinion.

This arbor sometimes works too easily in the centre pinion and allows the hands to drag. To tighten it, a good plan is to rough it slightly by laying it on a fine sharp file and placing another file on the top of it. Roll it between them, applying some pressure. This impresses the teeth of the files on the steel evenly all over and tightens it. If too much, it can be smoothed with a burnisher again until easy enough.

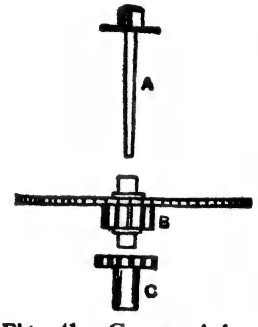

Fig. 41.—Centre Arbor A, Centre Pinion B, and Cannon Pinion C of Swiss Watch

Tightening up Cannon Pinion. — If a cannon pinion is too loose on the arbor to hold tight (it should be quite tight), it may be tightened by inserting a bristle from the watch brush in its centre and pushing on the arbor again. As it does not turn on the arbor, the bristle does not wear away. This method is better than hammering or burring the arbor, or squeezing up the cannon pinion, as it damages nothing.

Barrel, etc.—The barrel in a Geneva bar movement is also made differently. The arbor and ratchet are in one piece, and the part of the barrel arbor to which the mainspring is hooked inside the barrel is screwed on to the arbor proper, holding the barrel and bar together. So to take such a barrel and bar to

pieces for cleaning, first remove the stopwork, then the barrel cover, then the mainspring, and finally, holding the winding square in a key, grasp the centre piece of the arbor with pliers and unscrew it. In a few watches on this plan the inside arbor, instead of being screwed on, is pinned on by a steel pin going right through from side to side. There is often a difficulty in getting the pin out; but patience will generally be rewarded.

Replacing Wheels, etc.—The escapements of bar watches are quite easy to take apart and put together again, each piece being held by a separate cock or bar. But in watches in which the top plate is divided, the centre wheel and barrel being under one portion and the third, fourth, and escape wheel under another, trouble is often found in getting the top pivots into their holes. A very thin pair of tweezers is required to manipulate the wheels, and a light touch is necessary to keep a gentle pressure on the plate or bar while the pivots are being got into position. Force must not be used. When the third pivot is in, insert the nearest bar screw to hold the top plate, and then pay attention to the others, so preventing the first one getting out again while trying to get the remainder in.

CHAPTER IV

Cleaning and Repairing Swiss Cylinder Watches

The Cylinder or "Horizontal" Escapement.—Thousands of cheap Swiss watches (see Figs. 42 to 42B) having the cylinder or "horizontal" escapement (see Fig. 43) are still made. (It was called "horizontal" to distinguish it from the earlier verge escapement, which was vertical.) The points to look to in these watches are the following: An inspection of the cylinder will show that, where the escape-wheel teeth act on it, it is cut away to half a circle. A little lower down it is further cut away to a quarter-circle, by a slot or "passage," as it is termed. This slot is to accommodate the flat part of the arms of the escape teeth, while the impulse faces act on the upper part of the cylinder.

It is important that the flat part of the escape wheel should not touch either the top or bottom of this slot or passage. To prevent this, the endshakes of the escape wheel and cylinder must be carefully attended to, and reduced to quite a small amount. If a cylinder watch is held to the ear while it is going, first dial-up, then dial-down, and the escape wheel touches, it can be heard to scrape, and the height of the cylinder altered slightly to correct it.

The lower pivot of the cylinder is held in a

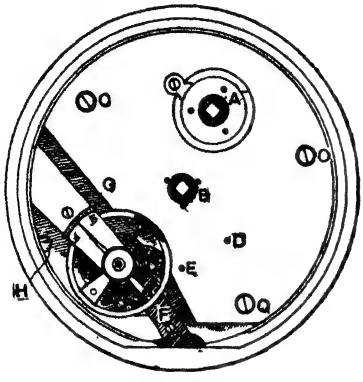

FIG. 42

Fig. 42.—The Movement

A, Click and ratchet; B, Set-square; C, Pillar screws; D, Third wheel pivot hole; E, Fourth wheel pivot hole; F, Escape cock; G, Balance cock; H, Case screw

Fig. 42A.—Bottom Plate, showing Motion Work:

A, Dial feet holes; B, Barrel arbor; C, Third pivot hole; D, Fourth pivot hole; E, Escape pivot hole; F, End-piece; H, Hour-wheel; I, Minute-wheel

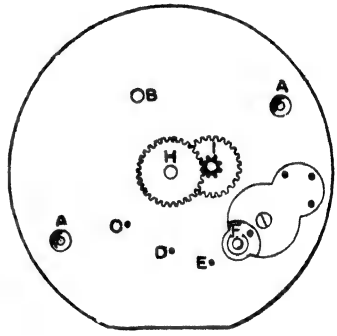

FIG. 42A

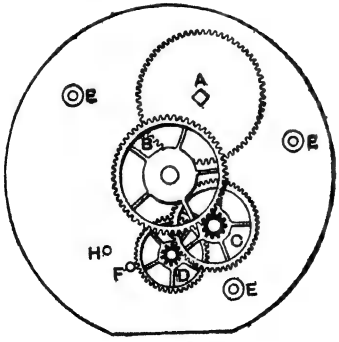

FIG. 42B

Fig. 42B.—Top Plate removed, showing Train

A, Barrel; B, Centre wheel; C, Third wheel; D, Fourth wheel; E, Pillars; F, Escape pivot; H, Cylinder pivot hole

Figs. 42 to 42B.—Three-quarter Plate Geneva Cylinder Watch

"chariot" screwed to the pillar plate, and packing this a little will lower the cylinder a trifle; or removing burrs, etc., will raise one. Or if the cylinder needs advancing towards the escape wheel to make the depth deeper, by bending the steady pins of the "chariot," it can be done. Fig. 43 shows the flat of the escape wheel in the cylinder passage.

The depth just mentioned is a particular one. The points of the escape teeth must just lock. To test this lead the balance rim round with a peg point and watch

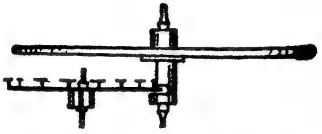

Fig. 43.—Cylinder Escapement

Fig. 43A.—Correct Locking of Teeth in Cylinder Escapement

the escape wheel. The moment a tooth drops, reverse the balance. If the tooth has locked properly, the escape wheel will stand still for a moment before the next tooth unlocks and begins to advance. If it has not locked, the wheel advances immediately the balance is reversed. If they do not lock, the obvious remedy is to advance the cylinder a little towards the escape wheel.

As in the lever escapement, the teeth must just lock, and that is all. If the wheel stands still long when the balance is reversed, it locks too much, and the cylinder must be got back a little. Fig. 43A shows a tooth just "locked" properly.

Fixing Cylinder Pivots.—The cylinder of a horizontal watch is composed of a thin, polished steel tube open at each end. Into the open ends plugs are fitted, and the pivot is formed by turning the plug end smaller, and is therefore solid with the plug. When a pivot is broken, the plug is knocked out with a special punch shaped as shown in Fig. 44, a new one fitted, and the pivot turned and polished to fit the jewel hole. In knocking out the plug, rest the cylinder on a stake with graduated holes in it. Let the brass collet rest on the stake and gently tap the punch.

In most cases the plug comes out easily; but sometimes the brass collet will shift first, especially when

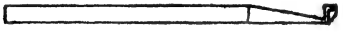

Fig. 44.—Punch for Removing Cylinder Plugs

the plug is very tight. In such a case, to start the plug, use a stake with coned holes, and when once started the plain-hole stake can be used; select a hole that exactly fits the plug and that will not let the cylinder body come through.

To turn the pivot, warm the cylinder gently on a brass plate or over a flame and run it full of shellac; this makes it solid and firm to turn and prevents breakage. Also, if turns are used, fix a turning ferrule on by means of shellac. If a lathe is used, cement the cylinder in an ordinary wax chuck having a coned hole into which the bottom pivot of the cylinder is firmly pressed, and run it true in the lathe while the cement is warm by means of a pointed watch-peg.

Whenever a cylinder is put in the lathe or turns, the hairspring is removed, and the cylinder filled with shellac to strengthen it and prevent breakage. The shellac is afterwards boiled out in a spoon with spirit of wine or methylated spirit, held over a lamp flame.

The little pin in the balance rim is the "banking pin," and its purpose is to prevent the cylinder from turning too far round. It comes into contact, when the balance vibrates too far, with a fixed upright pin in the back of the balance cock. When the watch is exactly in beat, and the balance at rest, the pin in the balance rim should be exactly opposite to the fixed pin in the cock, so as to allow half a turn in each direction before it comes in contact.

If the balance vibrated more than half a turn in one direction, the point of an escape-wheel tooth would enter the back of the cylinder opening and lock it. If in the other direction, the edge of the cylinder opening would strike an arm of the escape wheel, and cause it to recoil.

A banking pin is placed in the balance rim of both verge and cylinder watches, while in a lever watch there are two brass banking pins fixed in the plate to limit the angular motion of the lever (see a later chapter, pp. 70 and 71). They should be in such a position that the lever has just a little shake or freedom when against either of them.

A frequent cause of trouble in these watches is a lack of flatness in the escape wheel, causing some teeth to be free in the cylinder "passage" and some to scrape it. Place such a wheel in a pair of callipers

and, holding a pointer against it, note the high or low part, and bend the arms by a brass punch until it is true. This is a delicate operation. The wheel should be laid on wood, with the pinion through a hole to accommodate it, and a rounded brass punch placed on the arm to be raised. A tap in its centre will raise the rim at that part by bowing the arm downwards, and thus throwing the end up.

Removing and Replacing Balance Spring of Cylinder Watch.—The inner end of the hairspring or balance spring is pinned into a "collet" which fits friction-tight upon a shoulder turned on the balance centre. The outer end of the spring is pinned into a "stud," which is generally of brass, square in shape, and has a little pivot which is pressed into a hole in the balance cock. To remove a hairspring from the balance, lever the collet up with a thin and sharp pocket-knife blade, and remove it complete with its collet.

To replace the spring, so that the watch is in beat, place the balance upon a graduated steel stake, lay on the spring with the stud against a small dot usually found in the balance rim, and press the collet down to its seating with a pair of tweezers. If there is no dot, place the spring on so that when the balance is at rest the cylinder opening faces the escape wheel. If on trial it is not quite right, turn the collet round by inserting the thin blade of an oiler into the cut in the collet.

For removing the cylinder and spring from the balance cock, do not unpin the spring, but detach the

stud by pushing it through from the top and levering up with the pocket-knife blade.

To pin a hairspring into its collet, place the collet on a broach held in the left hand, pass the spring over it, and insert the end, which must be bent inwards for the purpose. File up a thin tapered brass pin, and flat the side that lies next the spring. Insert the pin and cut off its surplus length, then cut it half-through with a pocket-knife to just the length required, insert it again, break it off where cut, and finally press it home. Then true the spring.

Fitting Cylinder to Escape Wheel.—The first step in fitting a cylinder to an escape wheel is to test the cylinder for size. An escape-wheel tooth should have the same shake or freedom inside the cylinder as the latter has between the heel of one tooth and the point of the next. A cylinder with too much "inside shake" and none outside is too large. One with too much "outside shake" and none inside is too small. Hold the cylinder between the thumb and fingers of the left hand and the escape wheel in the right, and place the shell of the cylinder between the point of one tooth and the heel of the next. Then try a tooth inside the cylinder. A cylinder height tool is generally used to take the heights, that is, to mark the position of the bottom pivot and seat of the balance on the brass collet.

The writer, however, adopts a method which is very simple. Unscrew the bar on the plate which carries the bottom cylinder jewel-hole called the "chariot," and screw on in its place a thin strip of

flat, smooth brass, or a piece of smooth card—"post-card" would do. Now make a small hole, which comes in the position of the jewel-hole. The hole must be just large enough for the arbor of the cylinder to pass freely through, so that the bottom of the cylinder rests on the card or piece of brass. The card must be smooth and rigid and lie flat against the plate to replace the chariot. The object is to form a resting place for the bottom of the cylinder. Now hold the plate and cylinder upright, and look across to notice

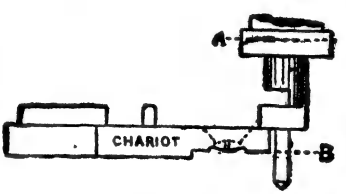

Fig. 44A.—Fitting Cylinder to Balance Wheel

if the rim of the escape wheel passes freely in the passage of the cylinder. If the lower part of the cylinder is foul of the rim, turn away the bottom which rests on the card until it is free. Next look straight across the top of the escape cock, and make a scratch on the brass collet shown at A in Fig. 44A, just above the top of the escape cock to mark the seat of the balance. Now, if the cylinder is the right height for the escape wheel, with the bottom resting on the card, it is quite obvious it will be the same if the chariot occupies the same relative position. Therefore, unscrew the endstone and hold the bottom of the cylinder flush against the edge of the chariot, and

make a scratch on the arbor which comes level with the end of the jewel hole marked with a dotted line B. If the endstone is sunk below the surface of the brass, allow this little extra. Fig. 44A shows the jewel hole flush with the brass and dotted line, as in most cases. The cylinder is now filled with shellac, heated over a spirit lamp, and while soft a small brass ferrule dropped over the body or shell so that the whole forms a solid. Use a long-pointed graver and a weak horse-hair bow, and turn off the lower arbor at the scratch, which will represent the end of the pivot. Fit the balance on the brass collet at the scratch, turn a rivet slightly above the balance, and fit the spring collet to come down to the rivet. The top arbor is now shortened to a height equal to the distance between the two jewel holes. Remove both endstones, screw on the balance cock, and measure the distance between the two jewel holes with a douzieme or micrometer gauge, or the runners of a depth tool would do. Rest the bottom arbor of the cylinder on one jaw of the gauge and shorten the top arbor flush with the other jaw, and turn down both pivots and fit them to the jewel holes. Then boil the cylinder in a small pan of methylated spirit, to dissolve the shellac. When the lathe is used instead of the turns a weak tension must be employed.

Endshakes in a Cylinder Watch.—All the wheels of a watch require a little "endshake" just to ensure that they are quite free. The amount should be small, only just enough to be well visible with an eyeglass. If the wheels, balance, etc., be lifted by

the point of a fine pair of tweezers and let fall again, the amount of shake may be seen by watching the pivot in its jewel hole. In a cylinder watch it is necessary also to see that the flat of the escape wheel is quite free in the slot cut in the cylinder, touching neither the top nor the bottom of it. With an eye-glass it is easy to see if the bottom of the cylinder slot touches the bottom of the wheel when the cylinder is lifted, and also whether the top of the escape wheel arm (not the tooth) touches the top of the cylinder slot when the wheel is lifted. Endshake may generally be given by placing a little piece of tissue paper under the forward end of the cock to cant it up, or decreased by paper under the back edge of the cock. A cylinder can be lowered bodily in the same way by packing the under-chariot as well, or raised by getting the lower endstone up a trifle closer.

Repairing Broken Tooth in Cylinder Escape Wheel.—If the watch is not a very flat one, a tooth can be soft-soldered on to the rim of an escape wheel to replace a broken one. An old wheel of the same size should be obtained, and a tooth broken out together with a part of the rim on which it stands. Both surfaces must be tinned with soft solder before trying to unite them. The best way to heat the parts is to lay them on a small slip of brass, and hold the brass over a flame until the solder runs. When tinned, place the tooth in position, and hold it on with an old pair of tweezers; heat the tweezers and wheel together over a spirit-lamp flame, not in it, but well over the top, so as not to get too hot. When the tooth

settles down it will show that the solder has run. After soldering, the wheel must be well washed in hot water to remove all trace of the soldering acid. The best job is made by fitting a new wheel, the old wheel being removed by laying it on a stake with the pinion through a hole and driving the pinion through with a punch. The punch must have a hole in it to pass over the top pivot. Obtain a new wheel, and open out the hole very carefully by broaching until it can be driven tight on to its seating on the pinion.

CHAPTER V

Cleaning and Repairing English Going-barrel, Fusee, and Verge Watches

The Modern English Lever.—The modern English lever watch, whether keyless or key-wound, has a going barrel like a Waltham, and resembles that watch so closely that the directions given in Chapter II for cleaning and repairing the one will apply equally to the other. The main point of difference is that they are not so interchangeable in their parts, even when machine-made, and therefore there will be more hand-work required in their repair.

There are several small structural differences. For example, the pallets are generally "covered"—that is, the steel portion is slotted, and stones cemented in and polished off level with the steel. Such pallets do not readily break, and hardly ever need repair. But in some machine-made watches the pallets are made on the Waltham plan—"visible"—and may be treated in exactly the same way. By warming the cement, a covered pallet-stone can be advanced to alter the depth; but, generally, covered pallets are a little more difficult to handle.

The centre pinions of English watches are hardly ever "screw pinions," but are solid; and consequently,

when a mainspring breaks, the teeth or pivots, especially barrel teeth, may be damaged. To replace a broken barrel tooth, a hole is drilled in the barrel edge and is tapped. A steel pin is screwed in quite tight and cut off to length, and filed up to the shape of the rest of the teeth.

The mainspring is often fastened at its outer end in a different manner. Instead of the T-piece the end of the spring may have a hole in it, and a hook is fixed inside the barrel to hold it. When the hook is a good one, this method is to be preferred to the T-end, as it strains the mainspring less, and causes less breakages. When a barrel hook gives way, the hole should be retapped and a new hook made from soft steel wire or very hard brass, and screwed in quite tight. The inside should not project much more than the thickness of the mainspring, and should be undercut to hold the spring close to the barrel. It is useless to soft-solder the old hook in again, as is sometimes done. It will pull out almost immediately.

Dummy Wheel or Idle Wheel.—Another feature sometimes found in English lever watches with going barrels is the dummy wheel between the barrel and centre pinion. The object of this was originally to make the watch wind " to the left " in the same way as the older fusee watch with chain. Winding to the left was so distinctive a feature of the English lever, that it was at first hopeless to try and make buyers believe their watches were English if they wound " to the right." Consequently, when the fusee was abandoned and the going barrel came into use, the extra

wheel was inserted to fill up the emptiness of the frame plates and reverse the winding. It is still retained by some makers, but has been dropped by others.

In a few watches this idle wheel has been used as a safety device, and been arranged to throw out of gear upon breakage of the mainspring. It is then useful, but only a very few are so arranged.

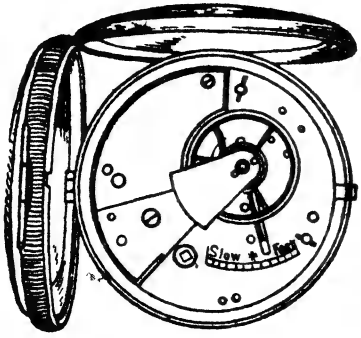

FIG. 45

Fig. 45.—English Lever Full-plate Watch

Putting Together.—Assemble the wheels in the usual way, and place the top plate on with the pivots in their holes. Then lift the plate up slightly in the direc-

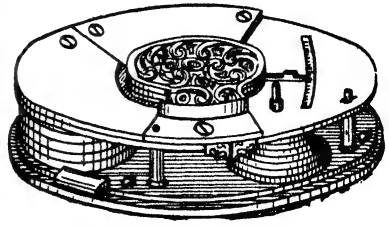

FIG. 46

Fig. 46.—Movement of English Fusee Watch

tion of the pallet holes with the tweezers, keeping the two plates steady with the thumb and fingers of the left hand. Now insert the lever. Slip the notch end under the potance or hang-down bracket, first inclining the lever at an angle of about 45 degrees to bring it away from the escape wheel, and let the bottom pivot drop in the hole. This is the general

plan. Another way is to reverse the assembling. Place all the wheels and lever in their respective holes in the top plate, and drop on the pillar plate.

The English Fusee Watch.—The foregoing remarks refer to the key-wind full-plate going-barrel levers, mostly machine-made; but there are still large numbers of the older hand-made fusee watches about, and owing to their good workmanship and hard material, they will be found in use for many more years, though their manufacture has practically ceased.

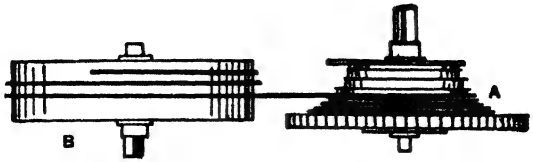

Fig. 47.—Fusee, Chain and Barrel

Two views of the English lever fusee watch are given by Figs. 45 and 46.

Fig. 47 shows the arrangement of the barrel, fusee, and chain. A is the fusee and B the barrel. The fusee is to equalise the power of the mainspring. When the spring is fully wound up it pulls strongly, and to counteract it the chain pulls on the small end of the fusee cone. When nearly run down, the spring is weak, and the chain pulls on the large end of the cone. Thus the pressure on the centre pinion, and consequently the actual driving power of the watch, remain constant throughout its daily run. It was thought that regular timekeeping depended on a constant driving force; but the modern lever-escapement

and pattern of hairspring are independent of such variations within large limits, and the absence of the fusee is not therefore felt. On the other hand, its omission removes a frequent cause of trouble—the chain—cheapens the watch and reduces the wear and tear.

Taking to Pieces and Cleaning.—A fusee English lever is taken to pieces and cleaned exactly as a going-barrel watch, except that precautions must be taken to first of all "let down" the mainspring. This is done by loosening the screw of the barrel click under the pillar plate, and, placing a key on the barrel arbor square, let the spring unwind itself. Sometimes the square is so short that a key will not hold it. Then try a pair of cutting nippers, and let it down a few teeth at a time by means of the click. If the watch is fully wound up, and there is nothing at all to grasp, another method must be followed. One plan is to remove the barrel bar, and, placing the thumb on the top of the barrel, ease it back, so that the chain can be unhooked. Then let the barrel run back under the thumb. There are other ways, and some advocate one way and some another (see p. 64).

In putting a fusee watch in the petrol for cleaning, the fusee should not be touched by petrol unless it is taken all to pieces, and it is not usual to take a fusee to pieces for cleaning unless there is something wrong with it.

Putting Together.—When putting the watch together, the chain is put on last, and needs a few directions. Turn the fusee round with a key until the

chain hook hole is outermost, and turn the barrel in the same way. Then hold the movement vertically, so that the chain may be dropped clean through from fusee to barrel. Place the barrel chain hook in its hole in the barrel, and put the thumb on it. With a key on the lower end of the barrel arbor, wind the chain up on the barrel, until the fusee end just reaches the hole in the fusee lower groove. With tweezers hook this in, and, proceeding to turn the barrel, wind the chain tight. Hold it so while the barrel ratchet is put on. Then wind the arbor up another half-turn to "set up" the mainspring, and screw the click tight. The watch can then be wound up, seeing that the chain lies evenly on the barrel and goes straight to the fusee grooves, or it may run over their edges and damage them.

Fusee Chain Repairs.—Chains and fusees are liable to many mishaps, and are a constant source of trouble. Chains break and hooks pull off. To mend a chain or put on a new hook, proceed as follows: Screw a block of boxwood in the bench vice, and lay the chain on it. Hold down the link with the finger nail, and insert a thin sharp pocket-knife blade between the links, and use it as a lever to raise the end link previous to removing the rivet. Do this just sufficiently to show the rivet end. Then fix a needle in a pinvice, and slightly flat off its point. Place the chain on a steel stake with a row of graduated holes, so that the rivet is just over a small hole. Then with the pinvice and needle press the rivet straight through. If it will not press out in this way, rest the needle on

it, and give the pinvice a tap with the watch hammer. Treat each broken end thus, and obtain a double link on one end and a single link on the other that match each other. Then temper the needle in the pinvice to a blue colour, file it up thin and tapered, and insert it in the rivet holes of the chain, giving it a gentle tap in tight. Cut it off level on both sides, and, laying the chain on the boxwood, hold it by the finger nail flat while the rivet ends are filed level with the links. Do not leave them standing up. Then lay the chain on a steel stake, and tap it with the hammer to close the link, and rivet the ends a trifle on both sides.

Repairing Fusee Ratchet and Clicks.—The ratchet and clicks inside the fusee get out of order sometimes. When this is so, take the fusee to pieces. Hold it by its square in a pair of sliding tongs, and push out the copper pin through its lower part. All can then be taken apart. Sometimes cleaning away the dirt and filing up the ratchet teeth will make it right. But occasionally either the clicks or ratchet must be renewed.

The old ratchet, attached by two brass pins, can be removed by prising up with a pocket-knife or a screwdriver blade. To judge the size of the new ratchet, lay it on the steel maintaining ratchet and see how it fills the space and goes up to the clicks. Then broach out its central hole to push tightly on to the fusee arbor flat down to the brass, the stumps of the old pins being flattened down level. Drill two holes through it as it lies, right down deep into the fusee brass. Fit brass pins, and drive them in tight.

Cut them off level, and place the fusee in a chuck in the lathe, and turn the pins off flush with the ratchet face, and cut out the centre of the ratchet around the arbor, so that the maintaining ratchet will lie close up to it. If no lathe is available, the turns may be used; but a special "fusee-turning arbor" will have to be purchased to hold the fusee.

New clicks are a troublesome little job. The old ones must be punched out from underneath. New ones are filed up from a length of "click steel," which

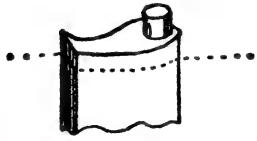

Fig. 48.—Making Click from Click Steel

is steel drawn in a strip, just the section of the outline of a click. Fig. 48 shows how a click is made from it. The end of the click steel is filed back, leaving the pivot standing up as shown. Then the click is cut off by a slitting file where the line is drawn across. The pivot must be easy in the hole, but not to shake about. The click is fastened in by riveting the end of the pivot just enough to hold it in position, but not enough to tighten it. Finally, the top surface of the click is flatted down level with a fine file, and the burr taken off its edges with a sharp graver.

Fusee Chain Pin.—Another little trouble is the pin on which the fusee end of the chain hooks; this sometimes breaks. To put in a new one, take the fusee to pieces, push out the old pin or its remains,

and fit a nice brass pin in the old hole, filing it flat on both sides so as not to project.

Other Fusee Repairs.—The fusee grooves also are liable to damage. A thin burnisher may be used to raise the edges when they get pressed down; but the greatest care must be used, or they will be spoiled.

The stop of a fusee watch is also liable to give trouble. See that it works freely, and its spring does not bind. Its end should be flat and true, not notched or rounded. If it fails, find out by observing whether the finger on the fusee passes above or below it. Then take the watch apart and adjust it accordingly, and try again.

When putting a fusee together, oil the surfaces well that come in contact, and the clicks. Pin it up finally with a copper pin, cut the pin off on each side with cutting nippers, and rivet the ends by pressing with the pliers. If the fusee winds too stiffly, it is pinned up too tightly, and can be eased by holding the main-wheel teeth in the fingers, and giving the end of the bottom pivot a smart blow with the hammer. This "beds" the copper pin and eases it. If brass had been used for the pin, the fusee could not be eased in this manner; hence the use of copper.

The Maintaining Detent.—The detent of a lever watch engages with the fine ratchet teeth cut around the edge of the maintaining ratchet, which is a part of the fusee. (It gives a little click every few minutes as it drops into a fresh tooth of the maintaining ratchet.) The duty of the detent is to keep the watch going while it is being wound up. Without a detent,

the watch would be liable to stop while being wound, and might not start itself again, and it would always lose a little time, depending on whether it were wound slowly or quickly. Also, without a detent, if the escape wheel had fine teeth, damage would result from the pallets catching them. Always see that the detent point is sharp and catches the ratchet properly, and that the detent spring acts correctly.

Although the detent may appear to be sharp at its point, its curve may be such that the point cannot enter between two teeth of the ratchet. This may be corrected by filing the inside of the detent to a curved shape. The detent spring can be easily adjusted to give sufficient pressure by bending it near its free end.

Overbanking.—Should the point of the detent be badly worn, the maintaining work cannot act and the watch will overbank when winding up. Overbanking also results when the safety pin in the lever is too far back; the pin then requires to be bent forward a trifle. The duty of this pin is to prevent the lever passing the roller between beats, or when the power is reversed as in winding, with faulty maintaining work. The guard pin, or safety pin, should be so far forward that when the balance is held round to one side, the lever will not pass the roller when tried with a peg point. But care must be taken not to bend the guard pin so far forward that there is no freedom against the banking pins. There must be a little "banking shake" against each pin, which can be tested by holding the balance half a turn round, first one side and then on the other.

The Verge Watch.—As but very few verge watches are now in use and there are none made now, it would be waste of space to describe the entire mechanism. Fig. 49 shows the general arrangement of the wheel work contained between two circular plates, on one of which is the dial. The barrel A drives fusee B, to which is fixed the first wheel or main wheel, which drives the second wheel C, this being known as the centre wheel, revolving once in an hour, and

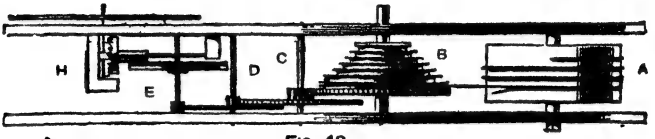

FIG. 49

Fig. 49.—General Arrangement of Wheelwork in Verge Watch

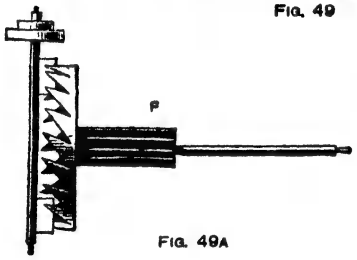

FIG. 49A

Fig. 49A.—Escape Wheel and Verge

carrying the minute hand. The centre wheel C drives the third wheel (to the left of D), which, in its turn, drives the fourth wheel (to the right of E). This, in a verge watch, is sometimes called the "contrate wheel," on account of the form of its teeth, which are upright instead of flat. The fourth wheel carries the seconds hands in watches that have seconds dials, and revolves once in a minute. The contrate wheel drives, by means of a wide pinion F, the escape wheel or "crown wheel," so called from its teeth making it

resemble a crown. The escape wheel acts upon the pallets or "flags" of the "verge," shown in fuller detail by Fig. 49A. The escape wheel is held in the following manner: A block of brass is fixed to the underside of the top plate; in it is a piece of brass sliding in a hole and carrying the back pivot of the escape wheel in such a manner that it can be advanced to adjust the action of the escapement. The other pivot of the escape wheel runs in a pivot hole in a slip of brass, called the "dovetail slip," adjustable in a groove in the potance or hang-down bracket H.

The escapement acts as follows: The verge is provided with two pallets, at right angles to each other. One pallet engages with the bottom edge of the escape wheel, and the other pallet with the top edge. An escape wheel tooth, pressing sideways upon a pallet, turns the balance about a quarter-turn round, and then slips off the edge; another tooth, on the other side of the wheel and travelling in the opposite direction, then drops upon the face of the other pallet and forces the balance back again, and so on. The balance is thus continually driven backwards and forwards through an arc of a circle.

This motion of the balance, when uncontrolled by any other force, was very erratic, and the first attempt to control it was by inserting a bristle for the balance to butt against at the extremity of each vibration. This caused the balance to rebound each time it was driven by the escape wheel teeth, and a more regular motion resulted. At a later date (about 1600) the balance spring or hairspring was introduced.

CHAPTER VI

Cleaning and Repairing Modern Keyless Watches

Swiss Keyless Work.—The Swiss keyless lever is one of the most general in the modern class of watches. Fig. 50 shows the movement or works of a Swiss keyless lever as seen with the dome of the case open. The first operation in taking such a watch to pieces is to let the mainspring down. Except when the mainspring is broken, the wearer usually winds it to the top, and if it fails to go he naturally imagines it requires cleaning. To take a watch to pieces, therefore, with the mainspring wound would be courting disaster. The wheels would fly out in all directions, and some probably be lost or broken. Hold the watch in the left hand and press the keyless button slightly with the thumb and finger as in the act of winding. The button which is fixed to the winding shaft A will throw the winding wheels B, C and D into gear and lift out the click E from the tooth in D which it holds. Click E is kept pressed in the teeth of the main winding wheel by a weak spring. With a screwdriver or the end of a piece of peg wood, press the click out away from the wheel, and let the keyless wheels run back gently, holding the button slightly as a brake. A small screw F near the edge of the plate holds the keyless shaft. Unscrew it and take out the button

and shaft. A large dog-screw G with one-third of the head filed away holds the works in the case. Unscrew it with the flat flush with the edge of the plate, and the works or movement will push out. Remove the hands, and the dial is usually fixed with two small screws (shown in Fig. 49) with a crescent cut in the head. Unscrew them until the feet are free to fall out.

The balance cock H, which is fixed with a screw, is next removed. Lift it out gently, and with it comes the balance, shown by a double circle, and the balance spring. The lever and pallets are on the same arbor and fixed with two small screws, sometimes one, holding the pallet cock. The pallets embrace the teeth of the escape wheel; the pivot or bearings of this wheel run in the large plate and the escape cock I.

The type of watch shown in Fig. 50 is known as a "bar movement," the various wheels running in separate "bars" or cocks. Remove the escape wheel, and pull off the "cannon pinion" with a pair of brass-nosed pliers. This pinion is at the other side of the plate, driven friction-tight on the "centre arbor" which is in the centre of the plate, passing through the "centre wheel" L. The fourth-wheel cock J is next unscrewed to remove the fourth wheel. The main winding wheel D is fixed to the barrel arbor by a steel lock disc with two small holes M. Place the points of a pair of tweezers in the two small holes and unscrew it, while resting a finger of the left hand against the centre-wheel teeth. The "centre" and "third" wheels run in the "centre bar." Remove the two

screws and take off the bar. The barrel bar is fixed with three screws. Remove it, and the keyless wheels and barrel are free to lift out. The great wheel is cut on the barrel edge. The barrel cover is snapped into an undercut groove. Insert the blade of a screwdriver in the hole at the edge, and the cover will spring off, leaving the mainspring visible.

Removing Keyless Watches from their Cases.—

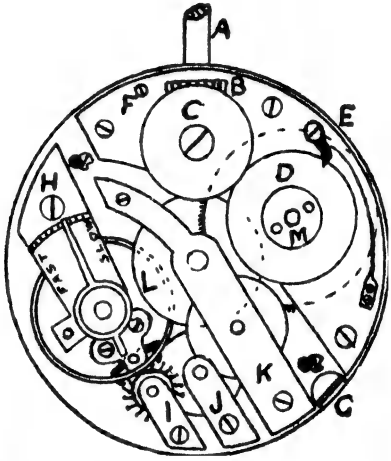

Fig. 50.—Bar Movement Swiss Keyless Lever Watch

With foreign watches, first remove the winding button and stem, and sometimes the set-hands push-piece as well. The method of fastening the winding stems varies. Some are fixed in the case pendant by a small set screw, which must be first drawn out; in others a set screw will be found on the back plate or bar of the watch movement. Failing a set screw, there will generally be a screw near the

pendant in the watch plate, which requires undoing a turn or two. When the set-hands push-piece requires taking out, a set screw will be found just on the case edge underneath the bezel snap, or else on the watch plate opposite it. In addition to taking these

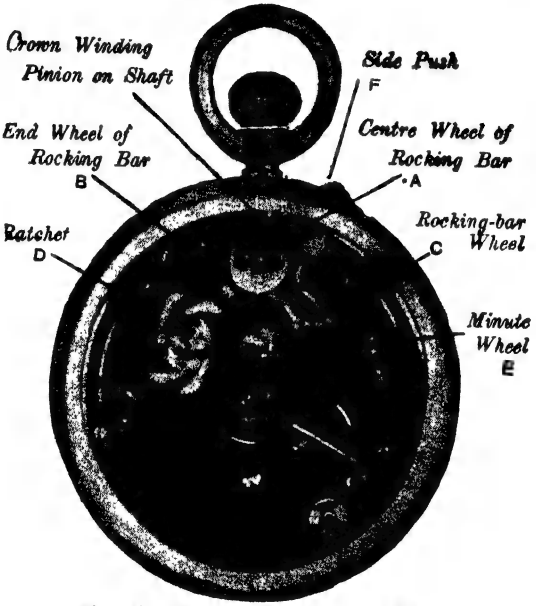

Fig. 51.—Rocking Bar Keyless Watch

out, dog screws will be found as usual, and in some watches these are underneath the dial, when the hands and dial must be first removed. Some few watches, in particular some of those made by Phillipe, must be taken half to pieces before they can be removed from their cases.

American Rocking-bar Keyless Work.—American

keyless work is made in great variety, but there are two general styles—the "rocking bar" (Fig. 51) and the "shifting sleeve." In the former the winding button is fixed to a winding shaft that passes through the neck of the case pendant, and on its inner end carries a crown-shaped pinion. This pinion drives the centre wheel A of the rocking bar. A, B and

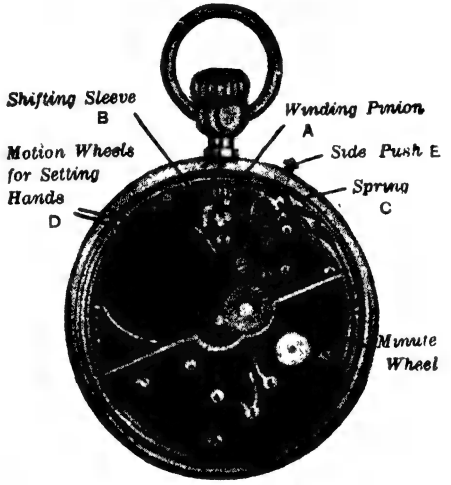

Fig. 51A.—Shifting Sleeve Keyless Watch

C are all mounted on the rocking bar. Normally, a spring keeps B pressed against the ratchet D, which is fixed to the barrel arbor. Then, on turning the winding button to the right, the rocking-bar wheel B is naturally pressed well into D, and the watch winds. On reversing the motion of the winding button, the teeth of B slip past the teeth of D, and no action takes place. To set the hands, a side push F is forced in,

and presses the rocking-bar wheel C into gear with the minute wheel E, and at the same time B is thrown out of gear with D. Then turning the button either way will set the hands. This is perhaps the commonest form of rocking-bar mechanism.

The following points need attention. The wheel B must engage well and deeply with the ratchet D. If not, the rocking bar must be given a little more movement, so that it may. A stop screw or other arrangement generally controls the movement of the rocking bar. Then the pinion on the winding shaft must engage deeply with the wheel A, or it will slip during winding. When the pinion is of the crown shape as in Fig. 50, a thin washer behind it will keep the depth deeper. When it is a bevelled pinion, the only way to deepen the action is to keep the wheel A down close to it by reducing all play of the parts, leaving only freedom of motion. All rocking bars require well oiling, and must work quite freely, but have no play or " lift " from the plate.

American Shifting-sleeve Keyless Work.—Fig. 51A shows a shifting sleeve. The button, as before, is on the outer end of the winding shaft. The inner end is squared, and on it slides the shifting sleeve B. The ratchet teeth on B engage those on A, and while the spring C keeps B up to A, A is carried round by the winding shaft, and the watch is wound. When the side push E is forced in, the spring C carries the shifting sleeve B down the winding shaft until it is clear of A, and its lower teeth engage the motion wheels D, and the hands can be set.

Fig. 52 shows a detail of A and B, while Fig. 53 (a back view) shows the portion of the keyless winding work that is mounted on the barrel bar. It includes the main winding wheel C with which the winding pinion A (Fig. 51A) engages, the ratchet D and click and click spring, etc. The third, fourth, and escape cocks have been removed to show the train wheels and escapement more clearly. The lever is of the " straight line " type, in which the balance, lever, and escape wheel pivots are all in a straight line. The " dog "

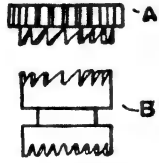

Fig. 52.—Winding Pinion and Shifting Sleeve of Keyless Watch

screws that hold the movement in its case can be seen at K (Fig. 53).

In both these kinds of American keyless work the side push is sometimes done away with, and a side lever used to throw the mechanism into gear for setting the hands; but, as a rule, this entails opening the case to pull out the setting lever.

Pendant-set Keyless Work.—Another way of eliminating the side push is to cause the pendant or button to do all the work. Such are the " pendant-set " keyless watches, chiefly Swiss and American. Nearly all English keyless watches have rocking bars and side pushes.

In pendant-set watches, pulling the winding button

sharply outwards throws the winding wheels out of gear and the hand-setting wheels into gear. This is effected in two principal ways. In the first, all the mechanism is in the watch movement, and the winding shaft goes right into the watch, like that in Fig. 51A. In the other the button is on a short-winding shaft, and is held by a spring-clip in the neck of the case.

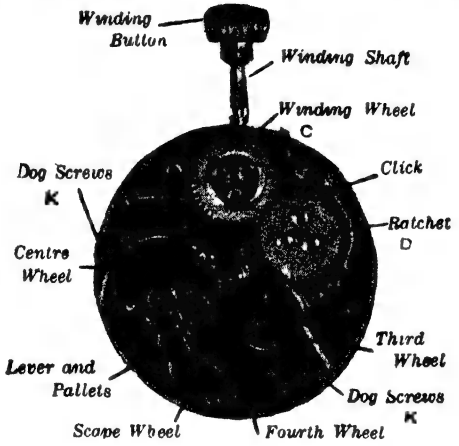

Fig. 53.—Back View of Shifting-sleeve Watch

These are usually found in American watches. When such watches give trouble in the winding, it is generally caused by a want of adjustment of this spring clip. If on pulling out the button the watch still winds and does not set the hands, the clip must be screwed outwards a little. A slot will be found in it for the insertion of a screwdriver blade. If the button when pushed in does not wind, but either sets the hands or does nothing at all, turn the clip inwards a little. A broken clip can only be replaced by a new one.

Making New Parts.—The keyless work of some American watches contains parts that are slender and difficult to make. When such parts break, new ones can be purchased ready to go in the watch. In Swiss watches it is not always so easy to obtain new parts, though generally something very near can be bought at a material dealer's. But frequently the only course is to take a piece of sheet steel or steel rod, and, using the broken part as a pattern, file up a new part, harden and temper it, and finish it to fit and act nicely. Practice in filing and patience are the only requisites to make keyless parts. When a new part is roughly filed to shape, hold it by a piece of binding wire, and heat it to a bright red in a spirit-lamp flame and plunge into water or oil. Clean off and rub lightly on a fine emery buff to brighten one side, and try it with a file to see if it is properly hardened. If hard, the file will not cut it. If hardened properly, lay it on a slip of brass and heat over the lamp flame until its bright side turns a deep blue. Then finish it to exact size, and brighten and smooth it all over. When hardened the part will be very brittle, and must be handled with care.

Tempering to a blue takes off the extreme hardness and gives it elasticity. Blue-tempered steel requires a fine-cut file to file it, and may be smoothed nicely by laying it on a cork and applying a fine emery buff-stick, emery-paper on wood, say a 3/0 or 4/0 grade.

Oiling Keyless Work. — All keyless work where friction takes place requires oil on the flat sides of the wheels, on shifting sleeves, winding shafts, and all

points of contact with springs. All screws in keyless work must fit well and be screwed home, or they will work loose, and may cause much damage.

Left-handed Screws.—The centre screw of a rocking bar, and sometimes the screw that holds the top winding wheel of a Swiss shifting-sleeve watch, is often left-handed, and requires turning to the right to withdraw it.

Removing Buttons.—The button of an American watch with a spring clip in the case pendant is screwed on the winding shaft, and may be removed by holding the inner squared end of the shaft with the pliers, and unscrewing the button with the fingers. The buttons of Swiss shifting-sleeve watches are generally driven on a tapered square, and may be easily driven off when required. In making a new winding shaft to such a watch, it is as well to drive on the button tight and apply a little soft solder, washing it well in water afterwards and oiling it.

Re-assembling Keyless Watch. — The correct order for assembling a watch is, the train first and then the barrel. Screw on the centre, third, and fourth wheels, then the escape. Try the endshakes and move the centre wheel very gently with a peg, and notice if the escape wheel stops gradually. Now turn the plate over with the wheels resting on their opposite pivots, and repeat the operation. This sensitive test of freedom is impossible if the barrel is screwed in first. The barrel and bar now follow. Oil the top hole, the bar under the winding wheels, and screw on the latter. Oil both centre holes, and fix the centre arbor and

cannon pinion. It is a great mistake to apply a lot of oil to the escape-wheel teeth and pallets. The best plan is to put a little on both pallet faces, and this will get evenly distributed on the wheel teeth. Too much oil tends to clog the escapement, and renders timekeeping impossible. No oil is required to the roller pin or notch. The balance spring is next placed on the balance, with the stud opposite to the dot on the rim, and the stud fixed to the cock. Screw down the balance cock, then turn the plate over and fit in the keyless wheels with button and shaft, giving plenty of oil to the keyless parts, and wind a few teeth. It will now be possible to test the escapement and see if it is in beat. Lead the balance round with a peg until a tooth of the escape wheel drops on to the pallet; release the peg immediately, and the balance should start off. Now repeat the operation, moving the balance in the opposite direction. If the balance fails to start off in both directions, it is out of beat, and the spring stud requires moving a little in the direction the balance was travelling when it failed to start off. Take out the winding shaft, fix the works in the case, then the shaft and button, and examine the winding and set-hands work. Finally, fix the dial and hands.

Cleaning Waterbury Watch.—In the older class of Waterbury watch, that is, the long wind, on removing the case at the back the words "Don't remove this unless you are a practical watchmaker" will be seen. Now, the only reason for this warning is that the very long mainspring may fly out all over the room. Therefore hold the cover down with the thumb until the

three screws are removed; then gently lift it so as to slip the blade of a knife across to keep the spring in position. When taking away the cover, look at the outer coil of the spring to notice particularly how it is arranged to act as a stop when the watch is wound up. Then unhook the spring in the centre or inner coil. To save two wheels an exceedingly long spring is used. Before unscrewing the movement top plate, examine it well, especially the duplex escapement, and after it is well brushed and cleaned, the pivot-holes are cleaned with pointed pegwood. Replace the few wheels in position and put on the top plate, getting the largest wheel pivot in first, next the one that stands the highest, and so on. The escape wheel when at rest must point a tooth at the groove in the bar of the balance, and will then be in beat. If not, unpin the hairspring and move it; then with best watch oil lubricate each pivot-hole at the top and bottom, a drop doing all that is required. As the Waterbury has a duplex escapement, the watch will be in beat if, when the balance is at rest, the impulse-pin points to the escape wheel. Test by pressing the large wheel to see that it beats all right, replace in the case, then the mainspring, and fix the outer coil. Also refix the inner cover with the three screws, replace the hands, which are simply pressed down, drop one spot of oil on the centre at the back, and replace the outer cover.

The short-wind Waterbury is easier to clean. By removing the small screw which holds the stem winder in position and the other holding its movement in the case, the work can proceed as already described, except

the mainspring, which is in a barrel as in an ordinary watch. There are two more wheels, on account of the shorter spring. Clean well the escapement as above and replace, when either watch will go well.

Cleaning Ingersoll Watches.—The Waterbury is not made now, at any rate by the original company. However, the Ingersoll is an equally, perhaps even more, popular make of cheap watch, and some patterns of it are known as the "Ingersoll Waterbury." The Ingersoll watch is fixed in its case with three or four screws. Assuming the works are removed, the cleaning process is simple. Remove the hands with a pair of nippers. Bend the dial feet a little to remove them from the holes. Loosen the two screws that hold down the balance bar, and then lift out the balance and spring with the bar. Let down the mainspring from the click and spring, unscrew the plates, and lift out the wheels. The cannon pinion, which is on the centre arbor, is removed by giving the latter a sharp blow with a brass hammer or a brass punch. Place the plates and wheels in a bath of petrol or benzoline to remove the thick oil, and afterwards brush them in clean tissue paper with a clean brush and chalk. Peg the holes clean, oil all the keyless parts and any other parts where there is friction, place the barrel and centre wheel in the plate, then the smaller wheels, screw the plate down and oil the pivot holes.

CHAPTER VII

Mainsprings: Selecting, Removing, Fitting, etc.

Inserting a Waltham Mainspring.—Mainsprings for Waltham watches are sold ready to put in; that is, they are of the correct width and strength, and have the end piece or T-hook riveted on. To put one in, first thoroughly clean the barrel, arbor and cover. Then begin at the outer end of the spring by inserting the T-hook into the small hole in the barrel bottom, coil in the spring ½ in. at a time with the fingers, pressing it well down as each turn is completed, until the centre is reached and all is in. If desired, a mainspring winder can be used; but the T-hook is apt to cut the fingers and catch. Putting in by hand is the best method, and a very little practice enables them to be done quite safely without distortion. Care must be taken not to bend the spring as it is coiled in, but just to ease it as the coils are pressed home.

Riveting T-hook to Mainspring.—If a proper Waltham spring is not available, an ordinary mainspring may be used in a Waltham watch by selecting one of the correct width and strength, and after breaking it off to the proper length, riveting a T-hook on its end. The hooks can be bought very cheaply. To rivet one on, first soften the end of the spring by heating it in the flame of a spirit lamp or gas jet for about ⅛ in.,

not more. Punch a small round hole near the end, and broach the hole out until the rivet on the hook just goes in. Smooth off both sides of the spring end with a fine file, and just take off the burr from each side of the hole by means of a countersunk or round chamfering tool, or a drill blade. Then rivet the hook on, and trim off its projecting ends, so that they are just long enough to hold properly in the barrel cover and bottom, but not so long that they project above or below the barrel when the watch is going. If these ends are

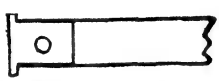

Fig. 54.—T-hook Riveted to End of Mainspring

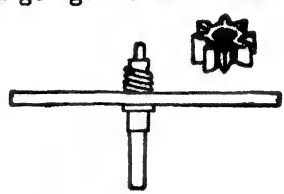

Fig. 55.—Centre Pinion Screwed to Arbor

allowed to project, they may stop the watch and badly score the parts with which they come in contact. The lower end, for instance, is apt to catch in the centre wheel, while the upper end will score the barrel bar or catch the balance.

It is a simple matter to fix the T from a broken spring to a new plain spring. File away the rivet against the spring, and insert a knife edge to remove it. Place the T with the pivot resting in a hole of a hollow stake, and give it a blow with a punch the same size as the pivot, when the latter will fall through the hole. File a new rivet to fit tight into the T and spring, and rivet over.

Fig. 54 shows a T-hook riveted to the end of a

spring. When the spring of a watch breaks, it causes a great shock to the train wheels, the barrel "recoiling" sharply. This sometimes bends a barrel tooth, breaks a leaf out of the centre pinion, breaks a centre-wheel tooth, or breaks off a centre or third pivot. In a Waltham watch this damage is avoided by making the centre pinion screw on to its arbor as in Fig. 55. It is cut with a left-handed thread, so that the pressure of the mainspring tends to screw it tight; but when the spring breaks and the barrel recoils, instead of offering resistance and causing damage, the pinion simply becomes unscrewed. Therefore, when a broken mainspring is found in a Waltham watch, look to the centre pinion, as it will be found unscrewed; unless it is again tightened it may be lost in brushing and cleaning the wheel.

Ordering Mainsprings.—There are so many different gauges for mainspring widths and thicknesses that it is best to buy a pair of gauges of some recognised standard, such as "Martin" or "Metric," and in ordering quote them distinctly. It is usual to keep to one gauge, and when ordering springs of another make quote the heights and strength they read in this gauge, and mention the name of gauge. Or, if any mistake is likely to occur, send the gauges to the mainspring makers, and make sure of getting the numbers required. In ordering a single spring it is always best to enclose an inch or two of the old spring; or a piece of spring of the width and thickness required. To remove a spring from its clamping wire it is only necessary to hold it firmly

between the finger and thumb of one hand, and with the thumb nail of the other hand slide off the wire. The spring will uncoil itself quite harmlessly.

The notches cut in the edges of the Martin gauge indicate the height of the spring, lever one side and Geneva the other. The sinks correspond with the strength for either lever or Geneva. For instance, a spring, strength 14, will be found to coincide in diameter with sink 14. Therefore, to find a spring suitable in strength for the barrel, place the latter over the sink which it fits, and select a spring to just fit the sink. The general run of lever mainsprings in height are from 8 to 14, with strength assorted 3 to 6 for the first three packets and 2 to 5 for the higher numbers. The numbers mostly used in Genevas in height are 1 to 6. Wristlet watches, which are now greatly in demand, are generally height 1 and 2, and very weak. These strengths should run 11 to 14, with 9 to 12 for height 3 and 4, and 7 to 10 for height 5 and 6. The best springs are usually of the highest price, and it is cheapest in the end to have the best. "Progress" and "BB" springs are good. "Cotton's" English springs are equal to any.

Mainsprings Breaking.—Occasionally an expensive spring will break at the first time of winding, but not often. Careless winding may also cause an occasional breakage, but if any considerable proportion so breaks, the fault is in the springs.

Inserting Stronger Mainspring.—To determine whether a sluggish action can be remedied by fitting a stronger spring, take a fine-pointed pair of tweezers

and apply a little forward pressure to the centre wheel or the barrel teeth. If this improves the action, a stronger mainspring will have the same effect. But this is obviously the wrong way to go to work. The cause of the poor action should be found and rectified.

Letting Down Mainsprings.—Instruction on this matter has already been given, but further notes may be useful. In a Waltham keyless watch there is usually a hole in the pillar plate opposite the click; push a piece of wire into the hole to release it. Other grades have a slot provided for the same purpose. When the click or ratchet teeth are broken, and there is a difficulty in letting down the spring, if a three-quarter-plate movement, tie the rim of the centre wheel to a pillar, and the barrel round the centre wheel with a thin piece of gut or wire to keep them in gear. Then unscrew the plate and remove the other wheels. In a bar movement, wedge the barrel first.

In the case of a lever fusee watch, the old-fashioned method of letting down the mainspring is to grip the fusee square in a good pair of hand tongs, and firmly hold both the tongs and the movement; carefully remove the bar under the dial, and take away the third wheel, and the chain can then be let down gently. Then throw out the click that holds up the mainspring, and the chain will come away freely.

In most English lever fusee watches the square of the barrel arbor is so short that it barely rises above the ratchet. This is awkward for letting down the mainspring when it is necessary to take the watch to pieces. The above method, necessitating the removal

of the back bar and the third wheel, entails loss of time; besides, as the spring is run down, the great wheel tends to rub against the plate, thus marking it. The following is a good plan to follow when the square is short: Remove the balance and wind up the watch fully. Then take off the main plate, and with the point of the tweezers inserted in the slot in the barrel lid, bring the barrel round a little towards the fusee; this will cause the chain hook to drop from the barrel. Now, with the thumb of the left hand pressing on the barrel, let it run down slowly. All that has got to be done now is to remove the barrel, take off the maintaining power, and the watch is ready to come to pieces.

Replacing Mainspring of Keyless Wristlet Watch.—First the winding button and shaft is withdrawn by unscrewing the shaft screw. The movement is then taken out of the case. Unscrew the balance cock and place the balance away from safety under cover. Rest the top plate on a piece of brass tube, and give the end of the set arbor (which carries the minute hand) a sharp blow, using a brass punch, to remove the cannon pinion. The latter will then be easy enough to pull out. Many watchmakers use a brass hammer to strike the end of the set arbor, while the movement is held in the left hand. Unscrew the top plate, remove the keyless wheels, and lift out the barrel. Insert a wedge or screwdriver at the hole in the cover to remove the latter and take out the arbor. It is advisable to send the old spring and barrel when ordering a new mainspring. The material dealer will then see

that the new spring is suitable strength for the barrel.

The mainspring will require fitting, that is, breaking off to the required length, and making the hole to fit the hook in the barrel. The material dealer usually sends the spring wound in the barrel. Sometimes it happens to be the correct length, but is generally too long. However, place the arbor in the barrel, and notice the difference between the space occupied by the spring and the unoccupied space. They should be equal or, in other words, the distance across the spring should be a little less than the distance across the space. The worker will be able to judge at a glance if a coil or half a coil broken off would bring it the right length. The mainspring, when wound in the barrel, should occupy one half of the space, when the arbor is replaced to obtain the greatest number of turns when winding. Remove the spring from the barrel, and any breaking off is easily accomplished with the pliers. Soften about ¼ in. at the end in a flame, to make the hole, which can be drilled, punched, or cut with a three-edge chamfer. Nearly all wristlet mainsprings are hooked to the barrel with either a "loose piece" or "riveted piece," which grips the barrel hook. They take the strain off the barrel hook and are not so liable to be overwound or torn as a hole in the end of the spring. The riveted piece is easier to fit. Soften a piece of the old spring, make a hole near the end the same size as the hole in the new, and break off a piece about ¼ in. beyond the hole. Next file the flat end to a knife-edge so that it fits under the barrel hook.

File away any rough burrs round the two holes. Then file a piece of brass or iron wire to fit the holes, place the spring and piece on the wire, and rivet them together. Cut the wire off flush and leave as little rivet projecting as possible.

In the absence of a mainspring winder, the spring can be wound in the barrel by holding the latter in the left hand, and the mainspring in the right. Press the riveted piece in its place tight against the hook, work the outside coil round slowly, moving the left hand; work round the second coil and so on until the whole spring is in the barrel.

Fastening Cheap Swiss Mainsprings.—In some cheap Swiss watches the end of the mainspring will be found to be bent back into a hook. It is difficult to bend a spring like this without breaking it. The best course is to rivet a short piece of spring on the end in the reverse direction. The braces for Waltham and similar springs are bought ready made and riveted on. The spring only needs a round hole punching in its end, which is opened out by broaching to fit the rivet on the brace. The spring of a fusee watch has a round hole punched in it. This hole is opened by broaching and filing to an oval shape, leaving a knife edge on the outside to hold the hook. Oblong holes need a mainspring punching tool and are of no advantage.

Using Mainspring Winder.—In using a watch mainspring winder (a spindle having a ratchet to prevent running back), screw it in the bench vice, and hook the centre of the spring on the winder arbor. Hold

the barrel against the spring coils with the hand, and guide the spring in with the fingers of the same hand as the handle is turned. Practice is needed for doing this properly, as in all other things. The clip on bar on the top of mainspring winder, which is pivoted at the end near the handle, and falls in a slot at the other end, is intended to grip the spring at the hook when it is wound, so as to hold it when adjusting the barrel in position. This clip is of little or no use, not only because it requires filing to a hook shape, but when made it will only hold the old-style fusee spring, which has the hook fixed to it instead of in the barrel. This fusee form of attachment is nearly obsolete. As the clip is in the way of the winding operation, unless carefully adjusted, the best plan is to knock out the rivet and remove it. Winding a mainspring in a barrel requires a little practice, as already said. Place the first and second fingers of the left hand behind the spring, so that the chuck of the winder comes between the two fingers, and hold the thumb in front of the spring so that the end of the chuck touches the thumb. By this means the spring is kept in a line with the coils riding one over the other. As you wind with the right hand, grip the spring with the left as described. When the spring is wound tight, the ratchet and click will keep it from running back. It is then an easy matter to grip the spring with the thumb and finger of the right hand before removing the left. The left hand is then free to take the barrel and place it over the spring. Give the winder a few turns to wind in the last piece of spring. When a mainspring is fitted

with a pivoted brace, or any sort of hook, grip the hook with a pair of pliers when wound to the top, instead of the thumb and finger of the right hand, as the force and roughness of the brace would cut the finger on its running back into the barrel. When gripping the hook with the pliers, press the latter down tight on the other coils to keep them from slipping. For the sake of practice, select an old mainspring, and exert a greater force with the thumb and finger than that exerted by the mainspring, to overcome its resistance.

Adjusting Stop-work of Swiss Watch.—The stop-work of a Geneva watch is intended to allow the mainspring to make four complete turns. If the spring makes five turns without the stop-work on there is a turn to spare, which should be divided, the spring being set up half a turn, so as to prevent it running quite down; and there should be half a turn to spare when wound up, so as to prevent dragging at its hook. In order to adjust the stop-work so that it does this, place the star wheel in position so that the stop finger will butt against the wheel and prevent it running back, then wind the spring up half a turn, or as near to it as possible, with a square facing the star wheel; then put the stop finger on so that the spring cannot run back, but is permanently set up half a turn. Then, if wound up, only the middle four turns will come into action.

CHAPTER VIII

The Lever Escapement: Its Action, Correction and Repair

Action of Lever Escapement.—In the typical English lever escapement shown by Fig. 56, the escape wheel A has fifteen teeth, and rotates in the direction shown by the arrow; one tooth is shown resting on the locking face B of one pallet. In this position the escape wheel cannot move. The lever C is also motionless, resting against one of the banking pins D. If accidentally shaken while in this position, the guard pin E in the lever would come in contact with the edge of the roller F, and the lever could not move sufficiently to allow the escape wheel to go forward. This is the position the lever assumes between each beat of the watch. The balance and roller, in returning under the influence of the hairspring in the direction of the arrow, will cause the ruby pin G to enter the lever notch and carry the lever across. In so doing, as soon as the lever has been carried a little way, the escape wheel tooth is unlocked and goes forward across the impulse face H of the pallet. The motion of the lever is thus accelerated, and an impulse is delivered to the ruby impulse pin and balance. This continues until the tooth drops off the pallet face and another tooth falls upon

the locking face of the other pallet. The lever will then rest against the other banking pin, and the guard pin E will be on the other side of the roller F, having passed by means of the "passing hollow" in the roller opposite the ruby pin. The balance, on returning, carries the lever again, the escape wheel is released, delivers impulse, and is locked again as in the figure.

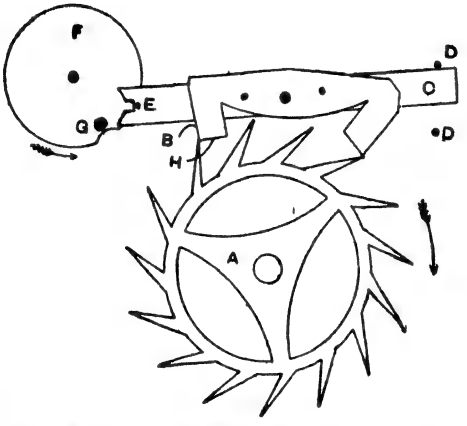

Fig. 56.—Action of English Lever Escapement (straight-tooth wheel)

The balance is quite free except when unlocking the wheel and receiving an impulse.

The lever escapement of a watch closely resembles that of a spring clock (fully dealt with in the companion handbook "Clock Cleaning and Repairing"), but the fork and roller action in a watch is a little different.

Waltham Lever Escapement.—The escape wheel of a Waltham watch is of the club-tooth variety (see Fig. 57), so called to distinguish it from the straight-

pointed teeth of the escape wheel of an English lever. The pallets are "visible" pallets, as contrasted with the "covered" pallets of an English lever. Visible pallets have the advantage that a pallet stone is easily replaced, but the disadvantage that they are fragile. They often get broken or come loose, and to replace one requires some knowledge of the correct action of the escapement.

In Fig. 57 one escape wheel tooth is resting on the locking face of the entering or first pallet. If, now, the lever is moved a little away from the banking pin, this tooth will be liberated, and pass across the inclined impulse face of the pallet, giving an "impulse" to the lever, until it drops off the corner and another tooth falls on the locking face of the exit pallet. The important point to notice is that the teeth points fall on the locking faces of the pallets and not on the impulse faces. They should not fall far up the locking faces, but just safely past the corners, so that a very little movement of the lever will liberate them.

In Waltham watches there are two holes in the bottom plate, through which the action of the teeth and pallets can be observed. It is no use observing them as the watch is going, for they move too fast. But the finger-tip should be placed on the balance rim and the balance led slowly round, and the action can then be studied at leisure.

Safety Action.—In the lever, just against the notch, is a little upright brass pin known as the guard pin or safety pin. Its duty is to prevent the lever passing the roller edge except during the giving of

impulse, when a little "passing hollow" allows it to pass. This "safety action," as it is called, should always be tested before leaving a watch and passing it as correct. To test it, hold the balance half a turn round on one side, and with the tweezers see if the lever can be made to pass the roller. Of course, undue force will make it do so, but gentle pressure should not. See at the same time if it has any tendency to stick or jam against the roller edge. If it does so, it shows

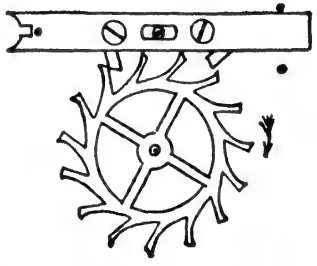

Fig. 57.—Action of Waltham Lever Escapement (club-tooth wheel)

that it nearly passes. If this is the case, the guard pin should be bent forward a trifle until it is safe. After doing this, the banking shake should be tried on each side to see that there is still some shake. Not much is needed, but it must have some, or else the guard pin will constantly touch the roller edge and act as a brake.

Of course, should there be a broken jewel hole in the balance cocks, there will be too much play; the watch will appear all right now and again, but the brass safety pin will eventually work wrong side. If the guard pin is bent forward under these conditions, the

roller will rub on the pin all along, and the watch will not go correctly.

Fitting a Guard Pin or Safety Pin.—The guard pin in the lever of an English watch is generally made from ordinary hard brass pin wire. In a very few watches it is made of gold. The wire should be very carefully filed up in a pin vice to a slight taper, almost straight, and highly burnished. It will then hold in well and cause very little friction against the roller edge when it accidentally touches.

Use of Depth or Depthing Tool.—The ordinary depth tool is required for scoring off the exact position of the pivot holes upon the watch plates, previous to drilling them. It consists of two parallel frames, hinged together and capable of being adjusted by a thumbscrew to any required distance apart. Each frame is provided with runners like a small pair of turns. In a usual pattern of this tool, used for adjusting and determining the distances apart centre to centre of wheels and pinions which are to mesh, there are two parallel sets of pointed steel rods—some are fitted with hollow ends—for the insertion of the steel arbors and pinions, the rods sliding in guides to accommodate the different lengths. The apparatus is then opened out or closed together by means of the adjustment screw at the bottom until the right depth of engagement is obtained between tooth and pinion, when the free external ends of the parallel steel rods then indicate, in the nature of callipers, the exact distance apart for the corresponding holes to be drilled in the clock plates.

A depth tool is also used for "pitching" an escapement, the escape wheel and the pallets being adjusted in the tool until correct; the depth is next transferred to the watch plates by means of the compass points of the tool, and the pivot holes are drilled at the points indicated. The roller depth is pitched by placing the roller on a small turning arbor in the depth tool with the lever. The pallet depth is correct when the wheel teeth just fall upon the locking faces of the pallets. If the teeth fall upon the impulse planes, the depth is

Fig. 58.—Tooth Locked; correct depth

Fig. 59.—Tooth Point on Impulse Face; shallow depth

Fig. 60—Tooth on Locking Face; depth too deep

shallow. This depth can be tested in the watch by holding the movement in the left hand with the tip of the forefinger on the balance. In the right hand, hold a sharpened watch peg, with which press gently on the escape-wheel teeth, urging the wheel forward. With the forefinger of the left hand slowly lead the balance round until a tooth just drops. Immediately let the balance go, and, if it has locked properly, the lever will be drawn sharply up to the banking pin; if it is too shallow, the lever will go back and the watch will tick rapidly. This requires some practice to test. Fig. 58 shows a tooth locked, having just dropped on to the pallet, and a correct depth.

Fig. 59 shows a shallow depth, the tooth just missing the corner of the pallet and falling on to the impulse face instead. Fig. 60 shows a deep depth, the tooth falling too far on the locking face.

Poor Action of Escapement.—It sometimes happens that a watch, when cleaned, has a poor action. This generally indicates a fault in the escapement, especially if in some positions the action is better than in others.

A bad action when the watch is on its face, with the balance uppermost, may be caused by any one of the following faults. The lever may touch the roller face. The lower endpiece may be cracked. The lower pivot may be bent or not come properly through its jewel hole. There may be something in the jewel hole itself. The balance may touch the top plate or the top of the barrel, or a hair or bristle from the brush may be sticking under a balance screw head or in the plate somewhere, and act as a brake.

If the action is poor when on its back, the following faults may be present. The top pivot may be bent or short, or the top endstone may be cracked. The hairspring may touch the balance arms or the balance cock. The balance arms may touch the hairspring stud or the index curb pins. The balance rim may touch the underside of the balance cock.

Some of the foregoing faults are easily rectified. Excessive endshake causes some, and can be reduced by placing a small strip of tissue paper under the back of the balance cock and screwing down.

A bad action when the watch is hanging up, with

the lever at the lowest point, indicates that the guard pin touches the roller, and the banking pins must be opened a little wider. Or that the ruby pin touches the bottom of the lever notch; in which case the pin must be warmed and set back a trifle. Or it may be caused by shellac on the ruby pin, or by cracked balance jewel holes.

To ascertain with certainty whether the fault lies in the balance pivots or jewel holes, or whether it is a faulty escapement, remove the roller and hairspring, and run the balance in its jewels to see if it spins quite freely in all positions. When it spins fast it will go over little faults; but watch it, especially as it stops. It should stop very gradually, and not suddenly with a jerk. See also if it stops always in one position. Careful observation will reveal the cause. If it runs badly on one pivot, examine that jewel hole and end-piece and pivot and so on.

Inserting Lever into Full-plate Watch.—To put a lever into a full-plate watch after cleaning, raise the plate sufficiently to accommodate the pallet staff in an upright position. Grasp the lever with tweezers and introduce it between the banking pins and place its lower pivot in the pivot hole. As this is done the plate can be gently pressed down to allow the lever to settle into position. The top pivot can then be got into place along with the others without any special difficulty. The knack of putting a lever in quickly will come with practice.

Correcting Steel Lever having Solid Dart.—In some Swiss watches the steel lever is made solid, so

that the roller edge works against a sharp edge of solid steel instead of a pin. Such a lever with a solid "dart" is difficult to correct when the latter requires advancing. The most satisfactory way is to file back the point of the dart flat, then soft-solder a very small piece of brass to the filed face, and afterwards trim up the brass by filing to the required shape and to a correct depth. Very great care must be taken to wash off every trace of the soldering acid with hot water, or the lever will rust. It is useless to oil steel that has been soft-soldered to prevent rust; nothing but immediately washing in hot water and drying quickly will be effective.

Oiling Lever Escapement.—All the pivots and the faces of the pallets require oil, but none should be allowed to reach the roller pin, the roller, or the banking pins, all of which should be quite dry and clean. There is practically no friction between the jewel impulse pin and the polished steel lever notch, as evidenced by the complete absence of rust. Wear only shows itself after very many years. If oil is used, the parts gather dirt and there is a slight stickiness or adhesion which seriously affects the action, and in a short time stops the watch. It also causes wear by accumulating dust.

Impulse Pin Slipping.—When the impulse pin gets out of the lever notch, it shows that the upright guard pin in the lever is at fault. Perhaps the guard pin is missing, or, if it is still there, it must be a little too far back, and requires bending just a trifle forward. The duty of the guard pin is to prevent the lever

passing over to the wrong side of the roller between beats. There is, as already explained, a hollow in the roller to allow the pin to pass at the proper time, but in any other position it should not be able to pass.

Altering Draw of Pallets.—In many cheap watches there is defective "draw" on the pallets, sometimes due to badly-shaped or worn teeth points, and sometimes to pallet stones not being placed at quite the correct angle. In each case it is hardly possible to correct the fault without going to the expense of a new escape wheel or pallets. In "covered" pallets some-

Fig. 61.—Pair of Twelve-degree Pallets; angles correct, draw insufficient

times a stone can be shifted to give "draw," by warming the pallets to soften the cement (see paragraph entitled "Re-cementing Pallet Stone" on next page), but this introduces another fault by altering the angle of impulse.

Thus, altering the draw of a pallet stone is a risky operation. When a wheel tooth fails to draw the pallet home the fault is usually in other directions. Therefore, to alter the locking angle or draw of a pallet is generally creating a new fault to overcome another. A "set" on the locking is the most common result. The greater the angle of draw the greater the resistance to unlocking, and both faults might cause the watch to stop. It is only advisable to alter the draw angle

when every other part of the escapement is correct. Fig. 61 shows a pair of ordinary twelve-degree pallets, cut the correct angles except with insufficient draw. Remove the pallets from the lever, and to grind the locking face of the entering pallet A, fix the pallets in a small brass clamp consisting of two pieces of flat brass screwed together with sunk heads, so that only just the locking face projects. It must be perfectly rigid, and is then fixed in the side-rest of the lathe and adjusted so that when the side-rest is advanced towards a flat polishing lap or disc rotating in the head-stock, the draw angle will be cut back two or three degrees. Both pallets cut back three degrees, as shown by the dotted lines on A and B, should be sufficient to alter any draw. A brass or copper lap is best charged with fine emery or oilstone dust. Polish with diamantine on a clean, fresh lap.

Re-cementing Pallet Stone.—To re-cement a pallet stone, the lever and pallets should be laid on a slip of sheet brass with a small hole in it for the top pivot to go through, so that the lever lies flat on the brass. Then lay a very small chip of shellac on the joint of the pallet stone and the metal of the pallets, and warm the brass plate gently until the shellac flows. Do not heat it until the shellac boils, but stop when it just gets liquid. Using, if necessary, two pairs of tweezers, press the stone home in its slot, and hold it until the shellac sets. Then try the action in the watch, putting in the escape wheel, pallets, and balance only, to see if the teeth "lock" properly and give impulse correctly. If the stone is in too far the teeth will not

lock, but will fall on the impulse face of the pallet. In such case re-warm the pallets, draw out the stone a trifle, and try again. Always remove superfluous shellac.

The same process exactly is followed in repairing a broken pallet stone. The lever should not be separated from the pallets to warm them, as loosening

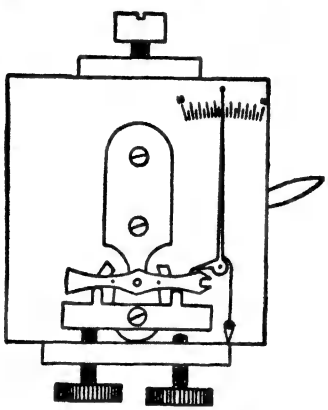

Fig. 62.—Tool for Putting Pallets in Angle

the screws that hold them together will surely lead to trouble, especially for an amateur.

Another method of drawing a pallet stone is to heat a pair of pliers over a spirit lamp, then grasp the pallets with them, and draw the stone with tweezers. The least trifle will correct the depth.

Tool for Putting Pallets in Angle.—A special tool is used for putting the pallets and lever of a watch in angle. The lever and pallets are held in a small clamp (see Fig. 62), a small tilting piece, actuated by the two thumbscrews, is forced against the lever,

and bends whichever pin is needed. The small recording hand at the side indicates, on releasing the screw, how much the pin has bent.

Rubbing Noises in Watch Escapement.—The judgment of the workman must be used to determine what rubbing noises indicate faults and what noises merely indicate roughness, etc., and experience alone can guide. A cheap common cylinder watch with a poorly polished cylinder and rough edges will make a continual scraping noise as it goes, and it may vary in intensity in different positions. Rough pivots and rough, badly-fitting jewel holes also cause noises. In general, a noise that keeps on, only varying in intensity as the position is changed, is merely caused by roughness of parts; but a noise that is only heard in one position, being totally absent in another position, is caused by either the balance, the escape wheel, or the lever rubbing against something they should not touch. Thus the balance rim may touch the balance cock, or the plate, or the escape-wheel cock so lightly that no difference in the vibrations can be detected. Or the balance arms may touch the coils of the hairspring, or the flat of the lever may touch the roller in the same way. An adjustment of the various endshakes will generally correct such faults. Any fouling of the parts, however slight, will seriously affect the timekeeping qualities of the watch.

A good watch should not make noises at all in the escapement beyond the locking and unlocking, that is the "ticking," and any noise in such a watch indicates a serious fault.

Fitting New Escape Wheel.—An escape wheel must be exactly the correct size, or the watch will not go. To fit a new one, a depth tool is required. First get a new wheel just the least shade larger than the old one. Mount it on the pinion, and "top" it true with a piece of oilstone held lightly against the teeth-points while the wheel revolves rapidly. Set the depth tool by the pivot holes in the plate and place the wheel and pallets in the tool in position. Try the depth and see that the teeth just "lock." If they lock too deeply, top the wheel again until correct, then transfer it to the watch and try it there. If too deep, top the wheel again. If too shallow, the top pallet hole will have to be opened out with a broach, drawn a little nearer to the escape wheel, and re-bushed.

CHAPTER IX

Balance, Balance-staff, Roller, and Impulse-pin Repairs

THE balance (see Fig. 22, p. 9) is a rim carried by an axis, axle, or staff, the latter revolving in jewel holes both top and bottom with end jewels; the top jewel hole is in the balance cock (Fig. 21, p. 7). The staff is shown separately by Fig. 63, on this page. The balance rim may be of steel and quite plain, or of brass, etc., compensated with screws as already illustrated; in the former case, any necessary regulation must be effected by altering the balance spring—the so-called hairspring; in the latter case, the screws provide a means of regulation and correction, as explained later.

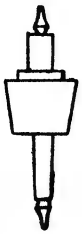

Fig. 63.—Balance Staff

Removing Balance.—Before removing the balance of a cylinder watch, either the mainspring must be let down with a key on the winding square while the click is raised, or the train must be stopped by inserting a fine pivot broach, bristle, or similar article under the third or fourth wheel. Then the balance cock with balance attached can be lifted bodily out, just shaking the cylinder free from the escape-wheel teeth. On the other hand, the balance

of a lever watch may be removed without taking any precautions to stop the train wheels, as the escape wheel is locked by the pallets.

Straightening Balance-staff Pivot.—A bent pivot should be straightened with a pair of brass-nosed pliers until it will run true in a pair of callipers. Then, if it is injured, or burred, it should be polished with a steel polisher and red-stuff mixed with oil, resting the pivot on a brass "bed"—that is, a brass runner in which is filed a hollow for the pivot to lie in. The end of a pivot should be nearly flat, just slightly rounded off. This flattening is done in the turns by passing the pivot through a hole in the lantern runner, and filing and burnishing the end with a pivot file. But if much of this is done, the balance staff will become too short (see also a later chapter).

Polishing Balance-staff Pivots.—Select a split chuck, and hold the balance staff in it to polish a top pivot, having first removed the roller and hairspring. To polish a bottom pivot, hold the upper part of the staff in a split chuck if there is sufficient to grip. If insufficient, a plain balance can often be gripped by its rim in a step chuck. If not, the balance must be cemented to a flat cement chuck by shellac, and run true while the shellac is soft by a peg point. The actual polishing is done by a steel polisher, the section of which is filed to fit a cone pivot. The polisher is filed clean, and charged with oilstone dust and oil mixed to a thin paste. It is then used as a file with light pressure. This removes the effects of wear, but leaves the pivot grey. To finish, file the polisher clean,

and recharge it with red-stuff and oil mixed to a paste. This produces a brilliant polish. When done, the shellac is dissolved by boiling in spirit in a spoon over a spirit-lamp flame.

Renewing Balance-staff Pivots.—If a watch lathe is available, hold the staff in a split chuck, having first measured its total height with a gauge. Then with a sharp graver turn off the remains of the top pivot, and turn a drilling centre for the drill to start in. Drill it as the lathe runs by inserting a sharp and dead-hard drill in the holder in the tailstock. Use turpentine as a lubricant, and keep the drill sharp. Do not wait till it ceases to cut before resharpening, or the bottom of the hole may glaze and refuse to cut. Drill rather more than the depth of a pivot, and as large a hole as possible. Then take a needle, and let its temper down to a blue. File it slightly tapered in a pin-vice to a good fit in the hole drilled. Insert it, cut it off, file its end flat, and drive it home. Then insert in the lathe as before, and turn the pivot to size, smooth it with oilstone dust and oil on a polisher until it just goes in the jewel hole, and polish it with red-stuff and oil. Finally round up its end and burnish it.

If only turns are available, the work will be more difficult. Run the bottom pivot in a safety back centre. The end of the broken pivot must be filed flat, and a drilling centre made by hand as central as possible by means of a pointed chamfering tool. The drill is inserted in a central hole in a plain brass runner, and held up to its work by the fingers. The turning and

polishing are much the same as in the lathe, except that runners and polishing beds must be used.

Nearly every pinion and staff can be drilled without softening, but should a balance staff be found that cannot be drilled for a top pivot, and it has a compensation balance, the only way to make a good job is to fit a new staff. The attempt to soften the upper part will spoil the balance.

Fitting New Balance Staff.—When balance-staff pivots break, it is best to fit a new staff complete by buying one ready made and riveting the balance on to it. Those who are quite expert with the watch lathe can put in balance pivots if they like; there is no objection to doing so, it is cheaper, and the necessary instructions have already been given.

To fit a new balance staff, the roller and hairspring must be removed from the old one. To remove a roller, hold it by brass-lined pliers so as not to mark its edge. If too tight to be moved thus, a "roller-removing tool" may be used. It may here be remarked that ingenious toolmakers have designed special tools for every operation in watch work; but the good workman can do without nearly all of them, and to buy them all would rapidly fill a large tool cabinet and empty a deep pocket. The hairspring collet can be carefully prised off with a thin and sharp pocket-knife blade. Then put the staff, with balance on, in the turns or the lathe, and turn off the riveted part of the balance staff face. Lay the balance on a stake, and with a flat punch drive the staff out at one blow.

If the new staff is correct, the balance will just

push on to the seating, and the steel can be riveted over all round just a little by using a crescent-shaped punch (a round punch with a hole in its centre half filed away). Do not hammer hard, or the balance may be sprung out of flat. Stop as soon as the balance is tight.

After either fitting a new staff or a new pivot the balance should be tested for "poise," and a little taken off a screw-head to restore the balance where necessary. If it is much out, place a "timing washer" under a screw-head where the rim is light, and, in addition, reduce one where it is heavy. The weight of the balance will then not be seriously decreased.

Turning a New Balance Staff. — Should the worker prefer to turn up the new staff for himself, he should first of all examine the old one as it rests in the plates, and notice if it was the correct height before it was broken. As a rule, it is correct, and the measurements can therefore be taken from it. If the balance appears a little too high or low, an allowance can be made in the gauge. Remove the balance from the plates, rest the body of the staff in a hole in a hollow stake, and drive out the staff with a hollow punch resting on the pivot shoulder. If there is much rivet over the balance, turn it away first in a split chuck of the lathe, or in the turns.

The lathe, or turns, may be used as a means of turning the staff. The former is quicker and more up-to-date; but there are many who still use the latter. The form of procedure is the same in each case. When using a lathe split chucks will be found the most

convenient for staff turning. For the turns a fine horse-hair bow and a small screw ferrule are necessary.

Select a suitable size hardened and tempered steel block, as supplied by material dealers. Then, assuming the watch is an English full-plate, fit the balance first, turning a square shoulder for it to lie against. Gravers are the most suitable cutters, and these should be sharpened before starting. If the point breaks, a rub on the oilstone will pay better than using extra pressure, which only tends to throw the work out of truth. The body or largest part is next turned to fit the spring collet. (In a three-quarter plate watch the collet is next fitted, but is on top of the balance instead of below.) The body is now shortened to the length of the old one, and the lower arbor turned to fit the roller. When the latter fits about half-way up the arbor, smooth it over with oilstone dust mixed with oil and a soft steel polisher, until the roller fits to the same height as on the old staff. To give the arbor a fine polish, a little diamantine mixed with oil and a bell-metal polisher might be used.

With the balance, spring collet, and roller fitted, take the heights as follows. Measure the distance from the seat of the balance to the bottom pivot of the old staff in a gauge; a douzieme or pinion gauge would do, or a pair of callipers. Then hold the new staff against the gauge and make a scratch, on the lower arbor that comes against the gauge, and turn back the arbor at the mark. The staff will then be the right height from the bottom pivot to the balance. If the bottom pivot of the old staff is knocked off, allow

for the length of the top pivot, as they are nearly always the same length; but, as a rule, it is the top pivot that is broken, as it is nearer to the weight of the balance. The gauge is now opened to the full length of the old staff, plus the length of a pivot (assuming the top pivot is broken), and then shorten the top arbor until it just fits between the jaws of the gauge. This will give the full length of the staff.

Another and more accurate method to attain this height is to remove both endstones, and measure from the outside of both jewel holes in a douzieme gauge, and to shorten the top arbor to the reading of the gauge. Finally turn down both pivots, fit them to the jewel hole, and burnish them on a Jacot tool. Use a very weak hair-bow in the turns, or a very weak tension in the lathe, for pivoting. Keep the gravers well sharpened, and provide a good supply of oil to the centres to keep the work running true.

An alternative method of procedure in making a solid steel balance staff for a lever watch is as follows: Cut off a length of tool steel rod and centre it in the lathe or turns. Rough out the whole staff, leaving it everywhere a little too large; then harden it in oil, brighten it, and temper it blue. Re-centre it in the lathe and turn the lower part down to fit the roller. Smooth this part with oilstone dust and oil, and polish with red-stuff. Then turn the lower pivot roughly and cut it to length, seeing that the roller is at the correct height for the lever. Test by standing the staff on the endstone with the hole removed. Then sight the correct height for the balance, turn its seating to a

tight fit, and leave a riveting edge. Turn to fit the hairspring collet a good fit. Then cut the staff to the correct length and turn the top pivot. Finally smooth and polish both pivots, round up the ends, and rivet the balance on. Then true the balance and poise it.

Riveting Cylinder-watch Balances—A plain steel stake with a row of holes in graduated sizes is used for riveting on watch balances. The cylinder collet is turned so that the balance goes tight down to a flat seating turned to receive it. The brass of the collet should rise a very little above the balance and the riveting face should be turned hollow, leaving the edge standing up ready to be riveted over. A hard steel punch shaped like a crescent is used, the cylinder and balance being turned round a little at each blow.

Fitting New Roller.—In fitting a new roller and pin in a lever watch, first procure a soft rough roller and broach out the centre hole to go on the balance staff to the correct height. Place it on an arbor and in the turns or watch lathe, turn the pipe to the right diameter and length, turn both sides of the roller flat, and reduce its diameter until, when on the balance staff and in the watch, the lever has just a little shake at each side when the guard pin rests against the roller edge. Then measure the position of the ruby pin-hole so that its pin will come well in the lever notch. Drill it with a small drill and broach it out until a pin fitted in it just enters the lever notch freely. Then file the passing hollow for the guard pin to pass at each beat. Try the action in the watch, and, if correct, harden the roller and temper to a red colour. Polish the roller

on the face, and especially on the edge, with crocus and oil on a steel polisher.

Fitting Collet and Roller to new Balance Staff.—If a hairspring collet is too easy on a new staff it can be closed up a trifle with a pair of pliers without hurting the spring. If a roller is too easy on the staff, lay it on a flat steel stake, and take a smooth round-faced punch, place it over the staff hole in the centre, and give just one blow with the hammer. This depresses the edge of the hole equally all round, and is generally effective.

If the roller will not go on high enough to be free of the lever, the solid portion of the staff must be turned back to allow the roller to go farther on. But the average new staff will be found to fit perfectly. Occasionally one of the pivots will require reducing a trifle to come properly through its jewel hole and reach the end piece. When this is the case, only polish it with red-stuff, and in about a minute or so it will be sufficiently reduced.

Poising a Balance.—A balance, as its name suggests, should be in perfect poise. If put lightly in a pair of callipers, it should not tend to settle in any one position. If it is heavier at one point than another, when the watch is lying horizontally there will be a great deal of side pressure on the pivots, causing wear and friction, while, when the watch is in a vertical position, as in the pocket, the balance acts as a pendulum instead of a balance. If the heavy spot is at the bottom as the watch is in the pocket, the watch will gain as compared with the rate in a horizontal

position. If the heavy part is at the top or to one side, the watch will lose in the pocket.

In poising a balance leave the roller on, but remove the hairspring and collet. Brush it clean, make sure that the pivots are free from oil, and place it on a poising tool of the parallel-knife-edge type. See that the knife-edges are clean and that the tool stands level. Very gentle tapping of the tool base assists the balance to settle with its lightest part uppermost. Do not spin the balance, but give only slight touches, enough to move it round half a turn, then tap and watch it settle. If badly out of poise it will swing like a pendulum. If only a little it will settle very slowly. Poising in a pair of brass callipers is only a very rough way, and does not reveal a slight error.

In the case of a plain balance, lighten the heavy part by filing the inner under edge of the rim; with a balance having screws reduce a screw lightly or add washers to the light screws.

The quarter screws of a compensation balance are those used for regulating the watch and also for poising the balance. Many cheap balances have no such screws. They can be distinguished by their tops being long and not pointed like the others. Two of them will be found at the ends of the steel cross arm and two at right angles to it, the four being equally spaced round the balance rim.

Small errors can be corrected by manipulating the four quarter screws, and larger errors by altering the weight of the screws. When perfectly poised the watch will be very nearly correct in different positions.

A loss in any one position generally indicates that when the movement is held in that position, and the balance is at rest, the top of the balance rim is too heavy.

Cementing in Impulse Pin.—A broken ruby pin in the roller is cemented in with shellac. First clean out the hole in the roller, then place the roller on a tapered brass wire. Select a ruby pin that fits, and put it in the hole, warm the brass wire a little in a spirit-lamp flame, and touch the ruby pin with the corner of a flake of shellac. This will run at once, and may be worked in the hole by sliding the pin to and fro once or twice. While the shellac is still soft, hold the roller up to the light, set the ruby pin upright in both directions, and see that its flat side faces outwards truly. When cold, take a sharp graver and flake off the shellac that surrounds the pin and any that may be on the face or sides of the pin itself, or in the roller hollow or on its edge.

A "roller warmer," as commonly used in cementing in a new impulse pin, may be a piece of steel or brass wire about 4 in. long, one end of which is filed taper, so that on it rollers of all sizes can be pushed. Where the tapered part ends, about 1 in. from the small end, a small piece of brass, such as a drill ferrule, is fixed. This is to hold the heat. It is used in the following way: With the brass-nosed pliers or a roller remover take the roller off the balance staff and place it on the roller warmer. Before removing the roller from the balance staff, a mark should be made on the balance rim opposite the ruby pin, so that it can be replaced correctly. Warm the brass collet in a lamp

flame, taking care that the roller itself does not go in the flame or get too hot. When warm, push out the stump of the old pin and proceed as above explained.

An alternative method is as follows: Remove the roller from the staff, dip it in petrol or benzoline, and brush it to remove any grease. Before fitting a ruby pin it is usual to clean off all the old shellac which becomes perished. A broach free from oil will suffice to clean the hole. Fix the roller on a piece of taper wire in a wood handle (a piece of pegwood would answer the purpose), and place the ruby pin into position in the roller with a very small piece of shellac resting on the back of the pin. Then hold the wire in a spirit flame near the roller until it gets red-hot and the heat runs up the wire and melts the shellac. Move the pin halfway through the roller and back again to give the shellac a chance to run through the hole. The flame should be held between the handle and roller, nearer to the latter.

CHAPTER X

Balance Springs or Hairsprings: Selecting, Fitting, Straightening, etc.

Selecting and Fitting Hairspring.—A hairspring about half the diameter of the balance having been selected, place the cock on its back, hold the spring central with the staff jewel hole, and notice which coil comes central with the index pins. Assume that it is the third coil, and this will then be the one to grip with the tweezers, and count to see if it is the right strength. Wristlet and all modern watches are made with an 18,000 train, which means that the balance makes that number of vibrations per hour, or 300 per minute, and as every alternate swing of the balance is counted for convenience, the spring should count 150 in exactly a minute to be correct. For preliminary trials, to see if the spring is suitable, count for ten seconds, which should give 25. Remove the old spring from the collet and place the new spring on the balance with the collet pressed down sufficiently tight to hold it. Grip with the tweezers the third coil that came opposite the index pins, and raise the spring to its full extent, so that the balance-staff pivot is nearly lifted off the board. Give the wrist a slight movement to start the balance vibrating, and count the number to a watch with a seconds hand beside the balance; or, better still, let

the balance pivot rest on the glass of a watch. Begin vibrating just before the seconds hand reaches 60, and at that number start counting. A spring that counts 24 in ten seconds is too weak, and should be gripped half a coil or so nearer the centre to shorten it, and be recounted. One that counts more than 25 is too strong, and requires holding nearer the outer end.

A spring that is too strong or too large for the index pins should be replaced by a weaker one. A spring a coil or so too weak can always be used by bending the outer coil out to come circular with the index pins.

When the spring counts correctly break off the outer coils, leaving about half a coil to spare. Place the collet on the board, and hold the spring over it to see how much of the eye requires breaking off, so that the spring passes freely over it. When the eye is broken off to the same size as the collet, bend the elbow to the same angle as the pin-hole in the collet, using a pair of tweezers and a point. A piece of white paper is now placed on a broach and the spring collet pressed down on top. The object of the paper is to give a contrast in vision to the collet. Insert a piece of waste spring in the hole and file up; then burnish and supply a brass pin to fit. Make a scratch on each side of the pin flush with the collet, remove the pin, roll it on a block, marking the scratches round with a knife, rub down the burrs, and break off the end beyond the nick. The pin will now be the correct size for the spring. Push the elbow of the latter in the collet hole, press home the pin, and break off at the notch.

The next procedure is to bend the eye or inner

coil up or down, in or out, with the tweezers to true it and then count the spring for a full minute to determine the exact part to pin in the stud, which is accomplished in the same manner as for the eye. To weaken a spring, let it out at the stud. When there is none to let out hold it with a piece of cork and rub it on a glass or metal block charged with oilstone dust. To strengthen it take it up at the stud.

Calculating Number of Vibrations.—The size or strength of the mainspring has nothing to do with that of the hairspring. That is governed solely by the size and weight of the balance and the number of vibrations per hour that the balance is required to make. The number of vibrations per hour may be calculated first by multiplying together the numbers of the teeth in the centre wheel, third, fourth, and escape wheels, dividing the result by the third, fourth, and escape pinions and doubling it. A fast train, such as is usually found, is 18,000 per hour, or 300 per minute. A medium train may be 16,200 per hour, or 270 per minute. A slow train is 14,400 per hour, or 240 per minute. Having ascertained the train, try a hairspring by temporarily fixing it on the balance, and proceeding as explained in an earlier paragraph.

Ordering Hairsprings.—Hairsprings for watches are usually in little paper packets, marked with the strength. In some makes the small numbers are the weakest springs and suitable for very small watches. Thus No. 4 is extremely small, and No. 24 very large and strong. A useful assortment would be alternate numbers from 8 to 20. In the "Progress" springs,

however, which are of a reliable make, the low numbers are the strongest and largest in diameter, and would suit the balances of large-size or gents' watches. The high numbers from about 30 to 40 would apply to ladies' or wristlet watches. To find the approximate size, place the cock on its back on the board, and select a spring whose distance from the centre to the outside coil is a trifle greater than from the jewel hole to the index pins.

Owing to the fact that different makers number their hairsprings on different systems, they cannot be ordered by number when one is wanted for a particular watch. The best plan is to send the balance to the material dealer and let him select a suitable hairspring, telling him the kind of watch it is for. The old springs had better be enclosed, as, though damaged, they will serve as a guide. It may also be necessary, at the same time, to send the balance cock or the index as a guide for the diameter of the new spring, to inform the material dealer as to the "train" or number of beats per hour required.

Making Hairsprings.—The operation of making watch hairsprings requires special skill. In making by hand flat wire is fastened at one end to the arbor of a winder not unlike a mainspring winding tool and is then wound up quite tight and kept flat by a brass guide on each side like a bobbin. When wound singly and released, the spring will open out a trifle only, and the finished spring is a "close-coiled" one. But when two or three wires are wound up one over the other, the results are more open in the coils. The best hair-

springs are afterwards fire-hardened and tempered, but common ones are left soft. They are hardened by being heated to redness in a box specially made to exclude the air, and then plunged into oil or water. They are tempered by being heated on a metal plate until a slip of bright steel placed beside them turns to a full blue. They are then polished by means of rouge and oil on a peg or wood polisher (this is very delicate work), and afterwards "blued" by heat on a metal plate over a lamp flame. These fire-hardened hairsprings are expensive, but are always used in the best watches.

Removing Hairspring from its Collet.—For unpinning a hairspring from its collet first remove the collet from the balance by inserting beneath it the edge of a very sharp pocket-knife blade and levering it up. Then push the collet tightly on to a broach; this holds it so that it cannot turn round. While on the broach, push out the pin that holds the hairspring by a needle held in a pin vice. The extreme point of the needle should be flattened off on an oilstone.

Making Hairspring Collet.—To make a collet in brass take a length of brass bushing wire with the central hole a little too small to fit on the balance staff. Hold it in a wire chuck in a lathe, or put it between centres in the turns and rough out the collet to the correct diameter and a little thicker than necessary, without cutting it off the end of the bushing wire. Then drill the hairspring hole, taking care that it is truly at right angles to the wire. Cut the collet off, and broach out its centre hole to go nearly home

on the staff. Then slit it with a slitting file, and place it on a turning arbor in the lathe or turns to finish. Use a polished graver, as this will leave a polished cut. Cut the collet down on its under side until it goes so far on the staff that the hairspring hole is level with the hole in the stud in the cock so that the hairspring will lie flat. Then cut the top surface down to the correct height, and put a neat bevel on each edge.

Handling Compensation Balance.—A compensation balance has a steel cross arm that is fairly strong, and if the balance is held in tissue paper in the fingers between the thumb and forefinger, the thumb being placed outside the rim at one end of the steel bar and the forefinger at the other end, considerable pressure may be applied without injury.

Cleaning Hairsprings.—The correct method of cleaning a hairspring is to dip it in petrol and dab it dry on tissue paper several times in succession. Then remove any dirt that remains with a pointed watch peg.

Straightening Hairsprings.—The straightening of a hairspring is a difficult and tedious job. First unpin the spring from its stud and place it on a watch glass upon a sheet of white paper. Then with two pairs of fine-pointed tweezers, one pair in each hand, proceed to reshape the faulty coils. Begin at the centre of the spring, and follow it round with the eye until the exact point of the first departure from trueness can be noted. Rectify this and proceed, always working from the centre to the outer coils. First get the coils

concentric, true, and at equal distances from each other. Then proceed to get the spring flat, working as before from the centre to the outside. To act properly a hairspring must be flat, true in the "eye," and all the coils must be free of each other and at an equal distance. The outer coil should pass freely between the curb pins and, when the balance is at rest, should not touch either curb pin.

A hairspring that is not central may be trued up as follows: First see if it is centrally pinned into its collet. Then detach the collet and spring from the balance and put the spring in position in the watch, fixing its stud properly. If true, as it should be, the spring will lie flat and free, and its collet will lie exactly over the balance jewel hole. The outer coil and stud must be manipulated until the collet stands central over the jewel hole. Then when put in place on the balance and once more put in the watch, all will be right. The portion of the outer coil that passes through the curb pins must be a part of a true circle, so that altering the regulator does not affect the shape of the spring.

Small alterations in time, such as a few minutes per day, can be made in cheap watches by opening or closing the curb pins of the regulator. Giving the hairspring more play makes the watch go slower; closing the pins causes the watch to gain. In a good watch this should not be done, and the pins should be close, each just touching the spring at all times, without nipping it, and the hairspring having no play at all.

Taking Up or Lengthening Hairspring.—The safest plan to "take up" or "let out" a balance spring is to remove the spring collet from the balance. Screw on or fix the stud to the cock with the spring and collet. Place the cock on its back on the board, and release the pin with a pair of strong flat-nosed (not pointed ends) tweezers, or a pair of very small pliers is sometimes used. Place one end of the tweezers on the small end of the pin and the other behind the stud, then press hard and straight. The rest needs no explanation. When a pin is lost, file a new one on a block perfectly round and almost straight, and burnish it. Then file a flat on the pin, reducing about one-fourth the diameter. The idea is not to kink the spring. Then press the pin in the stud with the flat side towards the spring. Make two marks on the pin with a knife at each end of the stud where the pin is to be cut, remove the pin, and rotate it on a block while the knife cuts a groove at each mark. Rub a burnisher over the pin to rub down the burrs, press the pin in the stud and break off at the grooves.

Hairspring Coils Touching Balance. — The only way of discovering whether the hairspring is free of the balance arms, the stud, or the balance cock, is to examine it closely with an eyeglass. Bring the balance to rest, and, holding the watch up to the light, look edgewise at the spring, balance, etc. Daylight should be visible under and above the spring, and it should lie flat and true. Then set the balance vibrating and again observe the spring to see if it "wobbles" through being untrue in the centre. If a spring is quite free

while the watch is held still, but nearly touches the balance or balance cock, it may actually touch when the watch is in wear and gets shaken about. In such a case a close examination will generally show that the blue colour is worn off the top or bottom edges of the coils, the spring being bright at those places.

Action of Balance Varying.—When a watch is horizontal the balance spins on one end of one pivot, and there is very little friction; consequently it spins very freely and through a large arc. When the watch is vertical the balance rests on the sides of two pivots, and there is more friction; the result is that, when in a lying position, the balance action is generally about one-eighth of a turn greater than when the watch is in a vertical position. If the hairspring is a good one the time-keeping should be equal, notwithstanding the difference of arc of vibration.

CHAPTER XI

Pivot, Pivot-hole, and Jewel-hole Repairs

Renewing Watch Parts.—All parts of such well-known modern watches as the Waltham can be purchased ready to put in, the watches being wholly made by machinery on the interchangeable principle. But if a complete watch were purchased in little parts in this way it would become expensive, and it is cheaper to put in new pivots in train wheels than to buy new pinions complete; still, for those who cannot put new pivots in nicely the pinions are convenient. Jewel holes and endstones, on the contrary, are best bought. On no account pass a broken or cracked jewel; the watch is sure to suffer.

Polishing Pivots.—To polish a pivot in the turns, the pivot is rested on a groove in a brass or steel polishing "bed," in which it revolves while a polisher is held flat upon it and moved to and fro after the manner of filing, but using very light pressure. The polisher is a flat strip of soft steel, and is moistened with oilstone dust and oil to smooth out the turning marks. When smooth, the pivot, polishing bed, and polisher are thoroughly cleaned and the surface of the polisher re-filed. Then red-stuff and oil is applied in the same way for a minute or two for the actual

polishing, and should leave a surface like a mirror. In a watch lathe the pinion would be held in a split chuck, and the pivot could run unsupported while being polished. The secret of pivot polishing is cleanliness and a perfect condition of polisher and polishing paste. Oilstone-dust and oil should be mixed on a "stake," a box with a hard steel plate on which to mix, and a lid to keep out dust. It should be mixed thin. The polisher should have a slight grain on its surface, left from passing a fine file slanting across it. This grain serves to hold the polishing material. Red-stuff must be kept in a similar "stake," but mixed rather thick and stiff. The polisher is re-filed and cleaned, and rubbed on the stake just to charge it with red-stuff and no more, very little being used. After the first "wet" has been rubbed down smooth and black, the pivot will be about half polished. Then clean off, recharge, and work down the second "wet," which should complete the polish.

Inserting New Pivot.—A new pivot is put in a watch wheel by drilling the pinion or arbor, as the case may be, and driving in a tempered steel plug. The plug is then turned up to shape and a new pivot formed by turning and polishing. To do such a job either a watch lathe or a pair of "turns" will be required, together with gravers, drills and polishers, and it requires considerable skill and practice in turning. A pinion is of hardened and tempered steel, and can only be drilled by a "dead hard" drill, that is, one hardened, but not tempered. Turpentine is the best lubricant for the drill blades. To soften a pinion

spoils it, and often spoils the wheel also. The steel plug is made by taking a needle and tempering it to a deep blue on a hot plate held over a flame. This is put in a pinvice and filed very slightly taper with a fine file, to fit the hole drilled. When filed, it should be burnished, as the smoother it is the tighter it will fit. It should enter the hole to half its depth, and then be cut off from the pinvice, filed flat on the end and driven right in with a punch, just leaving sufficient

Fig. 64.—Arbor Drilled

Fig. 65.—Arbor Badly Plugged; Plug not Central

Fig. 66.—Arbor Correctly Plugged

standing up to form the pivot. Figs. 64 to 66 show the work.

If turns are used for drilling the pinion or arbor, rest the wheel first on a stake in the bench vice, and dot a drilling centre with a fine pointed chamfering tool that is held and revolved in the fingers. The point of this chamfering tool should be formed of three polished flats, making a triangular cutting point. This centre can be made fairly true and drawn to one side or the other as seems necessary. Then transfer the wheel to the turns, put a ferrule on the pinion, and insert a drill into a runner having a central hole into which the drill can be pushed tight. This runner can be kept pressed up to the pinion as the latter is revolved by a bow.

The drill should be quite hard, kept sharp, and lubricated with turpentine. The moment the drill ceases to cut re-sharpen it, or the bottom of the hole will become burnished. It is principally the backward and forward motion of a bow that causes the bottom of the hole to "glaze" when drilling tempered steel; consequently a watch lathe in which the motion is always in one direction is better. While a drill retains its cutting edge the work will not "glaze." Having got the work glazed, the surface can be roughed by a piece of brass wire into which fine emery or oilstone dust and oil has been hammered at the tip end. Use the brass wire as a drill for a minute or so, then thoroughly clean out the hole and commence again with a sharp drill.

If the pinion is too hard to drill and there is no alternative to softening it, heat it to a pale blue, and remove the blue with spirit of salt, a momentary dip only, and wash well in water. Drill to a depth of at least a pivot and a half.

If a plug stouter than a needle is required, harden and temper a piece of steel wire, and file up in the pinvice to a tight fit in the hole. Let it be smooth and burnished, and the hole clean. Tap it in with a hammer until it is home. Then centre in the turns, drawing the centre with a file until true. Turn the pivot on it. Smooth it with oilstone dust and oil mixed to a thin paste, and used on a flat steel polisher as a file, the pivot revolving and resting on a brass polished bed, which is a brass runner suitably filed. When smooth, clean off, re-file the polisher clean, and

polish with red-stuff and oil used in the same way. Round up and burnish the pivot end in a "lantern runner."

It is generally best to finish a new pivot a trifle larger in diameter than the old one, and to open out the pivot hole with a broach to fit it. Most pivot holes get worn a little oval, and broaching will make them round again, and start the new pivot in a good, well-fitting round hole.

Straightening Pivots.—Bent pivots either in the train wheels or the balance staff may be straightened

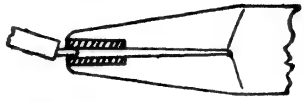

Fig. 67.—Straightening Pivot in Brass-jawed Pliers

by grasping the pivot in brass-lined pliers, as in Fig. 67. The shaded part of the jaws of the pliers represent pieces of brass. Brass does not injure polished steel, and, strange to say, hard steel can be bent in this way with much less risk of breakage than if steel pliers were used. Any old pair of worn pliers may be made to serve this purpose, provided they are not too large and heavy. First soften them by heating nearly to a dull red. Then file out two recesses, as in Fig. 67, and let in two pieces of thin sheet brass. Fix the brasses by soft soldering and put a rivet in each. To use them, hold the pivot and the pliers up to the light, so that daylight can be seen between the jaws. Then the bending can be watched.

To test for straightness, run the wheel in a pair of callipers while carefully observing it.

The safest method of straightening a cylinder pivot is with a small pair of pliers heated over a spirit lamp. The secret is to grip the pivot at the right place and bend it in the right direction. The pliers should be heated so that they can just be held with the naked hand.

Bushing Plate instead of Renewing Seconds Pivot. —Sometimes a seconds pivot is worn very thin where it works in the plate and is thicker farther up. In such a case, a long projecting bush is sometimes put in so that it reaches the large and unworn part of the pivot. This will often save the insertion of a new seconds pivot, which is a more difficult job than the putting in of an ordinary pivot on account of its having to be very firm, and because its length makes it slender and springy to turn. The bushing of pivot holes is dealt with in later paragraphs.

Repairing Pivot Holes. — A common and rough method of remedying a worn brass hole is to close it with a round-faced punch until it is too small for the pivot to enter. A new, smooth surface is then provided by broaching the hole with a round broach until the pivot just fits. The closing of a hole with a punch obviously shortens it, and the new bearing for the pivot has not only a shorter time for wear than it had originally, but cuts the pivot into ruts in a very short time.

When a brass hole is worn, the soundest method is to broach the hole out and fit a piece of hollow brass

known as "bush wire" or "bouchon." A long hole is thus obtained which will last for years. The same process applies to thin cylinder brass pivot holes. These thin holes have a short life, and to rebush them is the safest plan. Watch "bouchons" can be obtained from any material dealer.

A worn pivot hole may be drawn by pressing a pivot broach against one side of the hole only and revolving it; this is continued until the original round hole is drawn oval. It is then broached out round and bushed with a "bouchon," then opened out to fit the pivot once more.

Another method is to broach the worn hole, rivet in a solid stopping or plug, and upright it from the other pivot hole of the same wheel. Fix the plate or frame in the mandrel head of the lathe so that the centre comes tight against the hole, and screw on the plate or bar which has the new stopping. Hold a graver on the rest to catch the centre with the lathe running, and drill the pivot hole with a small drill slightly less in diameter than the pivot. Remove the plate and broach the hole until the pivot just fits it. Of course the pivot itself will need polishing or burnishing.

It is obvious that either the "bouchon" or the plug has great advantages over the system of punching up the hole, the latter spoiling the watch plate and remedying the evil for a very short time only. It will be understood that the bush is a piece of brass wire with a central hole drilled in it, and when inserted tightly and smoothed off level on both sides, the hole

is opened out by a pivot broach to fit the pivot. The result is a clean, new hole that will wear for many years, and the plate is not disfigured. A "bouchon" is selected that nearly fits on the pivot and the end is very slightly tapered with a fine file. Broach out the worn pivot hole from the inside of the plate, until the "bouchon" can be forced halfway in. Then break it off, file the projecting end smooth and flat, and with a flat-faced punch drive it in level with the inside surface of the plate. Take a pivot broach and open out the new hole to fit the pivot exactly. Always remember to use plenty of oil with a broach.

In first-class work the ends of the "bouchon" are faced off by turning on the faceplate or "mandrel" of a watch lathe; but often a smooth flat-faced punch will drive a bush in as described above, and leave the inside surface quite smooth and flat enough. A drill blade just turned round in the fingers will remove the burr from the edge of the hole, and a round chamfering tool will clean off the outer end of the "bouchon" level with the oil sink, and leave it smooth and polished. Do not file the inside end of the "bouchon" level with the plate, as it will mark and disfigure the plate.

In broaching a pivot hole, the plate should be held up to the light and the broach kept at right angles to the plate; and when opened out to fit the pivot easily, the wheel must be put in the frame alone and "run" to see if it spins quite freely and has the correct amount of endshake.

Removing Jewel Hole.—When a jewel hole is set in a plate or cock, it will be found to have a "setting"

on one side; that is, it rests in a recess in the plate and has a thin edge of brass burred over the top to keep it in.

To remove a jewel hole without risk of injury sharpen a watch peg and cut its point flat and of just the size of the apperture in the plate. With this peg held in the hand, push out the jewel bodily. The pressure will raise the thin setting and force out the jewel hole. An occasional breakage may result, but the great majority will push out in this way and not be injured.

Fitting Jewel Holes.—Jewel holes are sold by the gross. The stones are cut, drilled, and polished ready for use. They are arranged in two classes: Swiss holes, which are stones without the settings, and English holes set in a brass ring or setting.

To fit the setting of the latter to the hole or seat in the plate is a nice piece of work, and requires a turner of some experience. The hole is cemented with shellac to a lathe chuck, pegged true while soft, and the setting turned to fit the hole in the plate or cock.

To fit Swiss holes is a simple matter; they form two classes—small holes for escapements and larger varieties for third and fourth wheel holes. Remove the old hole with a pegwood punch, knocking it out from the small side so as to open the setting. Select a stone which just fits over the pivot, and the same diameter as the setting. Press the stone in, and rub round the setting with the point of the tweezers until the setting is flush with the jewel hole.

Fitting Endstones.—Endstones may be arranged in two classes—the loose and the set endstones. The former are held in their place by a cup and screws; the latter rubbed in metal, which forms a setting. To fit a loose endstone place the setting on a small box or piece of flat metal; select a stone which comes flush with the top.

Hold the box level with the eyes, to see if the endstone is the right height, and screw it down. When an endstone is rubbed in, knock out the old stone from the back with a small flat punch. Rub the edge up with a blunt point like the point of the tweezers. Select a stone to come slightly below the edge, and rub the edge down with a smooth steel rubber, using a little oil and pressing gradually all round the setting. When there is sufficient setting to hold the stone, warm a little shellac in the hollow and place the stone in, taking care to leave the endstone flat before it is fixed. In every case the endstone must be tight or the watch may stop or keep bad time if it rocks.

To fit a "rubbed" or set endstone, knock out the old endstone with a small metal or pegwood punch with the end smaller than the setting, so that the endstone will force open the setting with the blow and fall out. It makes no difference in how many pieces the endstone is broken. The object is to open the setting evenly. Select an endstone of suitable size that lies well in the bed of the setting, and rub down the projecting edge of the setting with a "rubber" (a smooth rounded point), or the point of the tweezers would do. Apply a little oil when rubbing over.

Size of Jewel Hole.—The main object in fitting a jewel hole is to select a stone just to fit the setting with a hole not too large for the pivot. If the hole is a trifle small for the pivot the latter might be burnished down to fit it.

As a matter of fact, there is usually no difficulty in finding a stone suitable to fit the setting of an ordinary size when loose holes are kept in stock. It frequently happens that the nearest-size stone is a trifle too large to go into the setting. In such cases the setting can

Fig. 68.—Jewel Hole, showing Metal to be Burnished over

Fig. 69.—Graver Point

Fig. 70.—Graver Ground to Shape

be burnished a little larger, bringing the side up straight at right angles with the seat of the stone. This can be accomplished by rubbing at A (Fig. 68) and applying a little oil.

If the stone is still found to be too large to fit the hole, the sides of the setting can be cut away with the point of a graver (Fig. 69), the sides of which are ground away at an angle as shown in Fig. 70. When the stone fits down on the seat, rub evenly all round the setting with the rubber, using plenty of oil. Fig. 68 shows a section of the setting open with a stone fitted ready for rubbing over.

Polishing Jewel Holes.—By the usual method stones for watch jewel holes are ground and polished with diamond dust carried by iron and copper mills or laps.

The interior of a hole is polished by centreing the hole in a lathe by means of shellac, and introducing a thin copper wire, into which diamond dust has been hammered. A high speed is necessary.

Cutting Setting for Jewel Hole. — For cutting a new setting for a jewel hole the watch plate is cemented with shellac to a brass face-plate about ½ in. or ¾ in. in diameter, run in the lathe. A spirit lamp held underneath the face-plate softens the shellac, and a sharp pointed watch peg is then steadied upon the hand-rest and the point inserted lightly in the pivot hole as the lathe runs slowly. This centres the plate, and as the shellac hardens very rapidly the plate remains true.

The cutters may be made from the tang ends of old flat files; these can be laid flat upon the T-rest, and with the aid of an eye-glass the setting is turned out to receive the jewel, the hole being opened and a slight ledge being left for the jewel to rest upon. A circular groove is then turned round the setting to leave an extremely thin wall of brass standing up all round the edge of the jewel. The jewel is then placed in, and the thin brass edge burnished over it by a round-pointed burnisher slightly oiled. Next, the plate is melted off the chuck and the shellac dissolved by boiling in methylated spirit in a metal spoon over the flame of a spirit lamp. Spirit of wine may be used in the place of

the methylated spirit, but the latter is just as good as the former and far cheaper. Shellac readily dissolves in it.

Tightening Loose Jewel.—A loose stone may be tightened by rubbing round the edge of the setting with the point of the tweezers, or a "rubber," a piece of rigid steel with a papered end and smooth semi-circular point, the shape of a lead pencil.

CHAPTER XII

Wheel Repairs and Corrections

Correcting Bent Teeth.—Bent teeth in barrel or train wheels do not often occur in modern watches, but they do occasionally. The blade of a pocket-knife is the best tool for correcting them, Fig. 71 showing a section of the little blade of a knife inserted between the teeth. A purchase is got against the firm root of the next tooth, while the blade is tilted over in the direction of the arrow to lift up the bent tooth.

Fig. 71.—Straightening Bent Tooth with Knife Blade

Replacing Broken Tooth. — If a tooth breaks off during straightening, a new one must be fitted by filing a slot into the wheel rim, fitting a piece of brass wire filed square, and soft-soldering it in. The best way to solder it is to lay the wheel with the wire in position on a piece of sheet brass, with a hole for the pinion or pivot to rest in, so that the wheel can lie flat. Apply a minute drop of killed spirit to the parts, and lay on a microscopic fragment of the solder. Then warm the brass gently over the flame of a spirit lamp until the solder flows into the joint. Immediately wash the wheel in water to remove the acid. Dry it and brush clean. Then cut off the wire

to the correct length with cutting nippers, lay the wheel on a cork, and flat down on both sides level with the rest, first with a fine file, then with a No. 3/0 emery buff. Finally shape up the new tooth with a thin fine file, to match the others.

Number of Teeth in Missing Wheel.—The number of teeth in a missing watch wheel may be ascertained by counting the train. The numbers of the centre and third wheels, divided by the third and fourth pinions, should give the number 60.

In Genevas and modern levers the usual train is: centre 64, third 60, with third and fourth pinions of 8.

In Geneva horizontals or cylinders the fourth is 60 and escape pinion 6.

In modern levers the fourth may be 70 and escape pinion of 7, or 80 with escape pinion of 8.

In old English levers the above rule will not apply. Frequently in them the fourth is 63 and escape pinion 7, and sometimes fourth 60, escape pinion 7.

In motion work, the cannon pinion and minute pinion multiplied together and multiplied by 12 should equal the hour wheel and minute wheel multiplied together.

The size of a missing pinion can be gauged from that of the wheel that drives it by means of a "sector," a tool that is listed by the dealers.

To replace a wheel one must be selected that, when placed in a depth tool with the pinion it drives and adjusted, the depth tool points coincide exactly with the pivot holes in the plates.

Freedom in Watch Wheels Defective.—It may

happen that the train wheels are incorrect in gearing with their respective pinions owing to the pivot holes being worn, which may be corrected by slightly broaching each hole over in the opposite direction to the way it is worn, and inserting a " bouchon " to fit the pivot. In some cheap watches the wheel teeth are thick and do not allow sufficient freedom in gearing with the pinions. In this case it is best to recut them in a rounding-up tool, using a cutter that will leave a wider space.

Using Uprighting Tool.—The uprighting tool is for marking the position of one pivot hole—generally the top one—after the other has been drilled, in order to make the wheels run perfectly upright. It consists of a flat table, in the middle of which is an upright lower "pump " centre that slides up and down. Over the table is a bridge carrying a similar sharp-pointed top centre that can be brought down to meet the lower centre exactly. To use the tool, place the frame in which the lower pivot hole has been drilled upon the lower pump centre, with its point in the pivot hole. Press the frame carefully down until it rests on the table of the tool with the lower centre still in the pivot hole. Then lower the top centre runner and bring it down on the top plate of the frame with slight pressure. This marks a "dot" and indicates the position of the top pivot.

Truing Wheels.—Take a case in which the third wheel fouls the fourth pinion. It is nearly impossible to true a wheel that is not circular by filing the teeth. The only practicable way of correcting the wheel is to

use a wheel-topping machine. These machines cost several pounds; but if the wheel in question is sent to a material dealer it will be topped true and returned for a few pence. Frequently it is questionable if topping or truing by reducing the high parts will be of any benefit, for if the wheel was once correct, there must be places where the depth is too shallow as well as places where it is so deep as not to run past the pinion, and when topped true it will be too shallow all round. Probably, in such a case, a new wheel will be the best remedy.

To ascertain whether the third wheel in a Geneva watch touches the bottom of its sink, it will first be necessary to true the wheel if it is not flat. In order to do this, place the wheel in a pair of turns, note where it is too low, and bend the arms up at the low point. Two or three attempts generally suffice to get the wheel true. In order to ascertain whether the wheel touches the sink, place it alone in the watch frame, and spin it. If the wheel is quite free, it will spin free; if the wheel touches, it will not spin long, and the scraping can be heard.

CHAPTER XIII

Regulating Watches: Remedying Gaining and Losing

Bringing Watch to Time.—To bring a watch "to time" means to make it keep correct time. To do so with a good watch, the curb pins must first be closed until the hairspring has no play between them. Then regulate by lengthening or shortening the hairspring, the regulator meanwhile being kept in the centre. Shortening the hairspring makes the watch go faster and *vice versa*. After each alteration of the hairspring, the watch must be set to beat afresh by turning the hairspring collet round a little.

To time a watch quickly, while it is going, after having drawn the hairspring in a little to prevent it losing—the watch has a seconds hand—set it to correspond with the seconds hand of a watch that is keeping correct time, and note the deviation in, say, five minutes. If there is no seconds hand, the watch can be timed roughly by counting the vibrations of the balance during one minute, using a watch with a seconds hand for comparison. Or, assuming the watch to have, say, an 18,000 train, the worker can take another watch also beating 18,000 per hour, and start the balances vibrating in the same direction together.

Hold the two watches close together, and note if the balance of one gains on the other.

Watches Gaining.—A watch will sometimes gain even when the regulator is pushed as far as possible towards "slow." The regulator of every watch is provided with two curb pins, between which the outer coil of the hairspring passes, and in such a case as that mentioned it may be found that the hairspring does not vibrate freely between the curb pins, but binds against one of them. If it already vibrates, opening the curb pins to give more play will cause the watch to go slower.

In such a case of gaining, some workers scrape the spring, but this may render the spring uneven. An alternative treatment, if there is not a spare spring at hand, is to take the spring from the collet and the stud, and fix it on a slab of ground glass, just as if it were mounted on the cylinder. The ground glass is covered with oil-stone dust. Pressure is now applied with a new and flat cork, turning and forming circles as large a possible, in order to prevent damage.

A Waltham or similar modern watch having a compensated balance and a breguet hairspring that will not come to time even when the regulator is pushed to its limit, should have the hairspring examined first. If this is cramped or not flat and free the watch will gain, and the hairspring must be first corrected before trying to regulate the watch. If the watch has a breguet hairspring and the spring has any play between the regulator curb pins, the watch will lose.

The curb pins should both touch a breguet hairspring, leaving no play between them.

A watch may gain when carried in the pocket, and when hanging up keep time. It is the rule with all watches, except the finest adjusted, to go slower when hanging in a vertical position than they do when horizontal, increased friction when in a vertical position being the cause. If the watch is always in a vertical position, in pocket by day and hanging up at night, and the temperature adjustment is perfect, the difference must be due to a positional error between pendant-up and 9 o'clock-up (in pocket), and may be due either to an imperfectly poised balance or to a small escapement fault, such as want of proper banking shake, a ruby pin that does not enter the lever notch quite freely, a little wear in the lever notch, the want of a "flatted" ruby pin, or to a roller that touches the lever. The poise of the balance must be tested, with the hairspring and collet removed and the pivots cleansed from oil, upon a poising tool, which is a pair of polished parallel straight-edges upon which the pivots rest. A good watch moderately well adjusted should vary less than five seconds per day either when continuously hanging up or when worn in the pocket. To go steadily when hanging up the watch must not be free to swing, but must rest steadily, or the motion of the balance will be affected.

Before altering a watch balance for timing purposes, always make sure that the fault does not lie elsewhere. For instance, a watch may lose because

it is dirty, or because of want of oil on one of the pivots, or because the hairspring has too much play between the curb pins. Or it may gain because of a want of freedom of the coils of the hairspring caused by touching each other, the balance arms or the balance cock.

Wearing in the pocket, as a rule, slows a watch a trifle on account of the constant movement of the body. But a large difference between the pocket rate and night rate may be a temperature error, caused by an uncompensated balance.

If quite satisfied that the balance requires alteration, thin "timing" washers may be placed under the heads of two opposite screws of a compensated balance to make it heavier and move more slowly, thus slowing the watch. Or, on the other hand, two opposite screws may have their heads reduced by filing, afterwards smoothing and burnishing them; this has the effect of lightening the balance and making it move more quickly. In good balances there are four "quarter screws" in the rim, with long taps, for making small alterations for poise and timing. In cheaper ones these are absent, and the use of "timing washers" must be resorted to. Turning the quarter screws out slows the watch; turning them in makes the watch go faster. Opposite screws must be turned equal amounts, or the poise of the balance will be disturbed. After making an alteration of this kind, the hairspring should be removed and the balance carefully tested on a poising tool.

In adjusting a Waltham or similar watch it is

not usual to "take up" or "let out" brequet balance springs. They should be left pinned in the same place at the stud as originally. The over-coil is theoretically formed to give the best result in timing, and any alteration from the stud is courting trouble.

There should be method in adjusting the quarter screws of a balance; of course, the other screws—the compensation screws—must not be touched. The quarter screws are the two opposite the end of each arm, and the two farthest away, forming a right angle with the first two. Always move two opposite screws at each time, or the four, so as not to throw the balance out of poise. Draw, that is, unscrew, the two opposite the arms half a turn each; wind the watch and give it a trial, making a note of alteration, and calculate the difference of the new trial. Assuming the latter gave a gaining of three and a half minutes, and the original fault is seven minutes a day, unscrew the two other quarter screws the same amount. If, instead, the trial showed a loss of one minute it would be known that the alteration was too much, and the same pair should be screwed in one-twelfth of a turn. When taking up a flat spring to set it in beat, move the spring collet round in the same direction the spring was taken up, and the same amount.

In a watch having a cylinder escapement gaining may be caused by the escape wheel and cylinder depth being too shallow; when this is so, the escape-wheel teeth run by without locking properly between each beat. To test it, lead the balance round slowly with

the finger tip and watch the escape wheel give impulse. The moment a tooth "drops," reverse the motion of the balance. If the escape wheel immediately advances again, the cylinder requires advancing towards the escape wheel. On reversing the balance there should be a very slight pause before the wheel again gives impulse.

Overbanking will cause a lever watch to gain; it takes place when the balance vibrates nearly one turn on either side of its position of rest. The ruby pin then strikes the lever horns and rebounds, causing a curious double beat when held to the ear. The cause is too strong a mainspring.

A cylinder escapement can be made deeper by shifting the cock or chariot, which is screwed to the pillar plate and carries the lower cylinder jewel hole. This chariot is, or should be, adjustable. Slacken the large screw, and it should be free to move slightly backwards or forwards to the escape hole. If it is not free to move, broach open the steady-pin holes, replace the chariot and see if it has "shake." If it is still tight, see what prevents it from moving. Either the screw head is too large in diameter, which would require reducing; or the screw hole in the chariot is not large enough; or the sides of the chariot are tight against the sink in the plate. In the latter case, file the edge to give it shake. The steady pins can now be bent in the opposite direction to the escape hole, to bring the chariot nearer the escape wheel, thus advancing the cylinder. Place the escapement in the frame and try the depth. The teeth of the wheel should drop well

on the outside of the first lip and on the inside of the second lip to be safe. Move the balance round slowly with a peg, and immediately a tooth drops move it round very slowly in the opposite direction and notice how far it is moved before the tooth moves forward. The balance should have a perceptible motion before this action takes place. If, instead, the wheel slightly recoils, it still misses locking, and the chariot requires to be pushed a little more forward.

Watches Losing.—The necessary corrections to be made when watches lose time will frequently be simply the opposite of those already described for remedying gaining.

As already remarked, there is more friction when a watch is hanging in a vertical position, and a watch may then tend to lose. In a new clean watch the difference may not be much, but dirt and wear soon increase it. For example, a watch that keeps excellent time when not worn, may, when carried, lose several minutes. Probably the fault is in the escapement. It will be either the lever and roller or the wheel and pallet depths that are shallow, allowing the wheel tooth to leave the locking face and get on to the impulse incline, so forcing the guard pin tight on the edge of the roller. This would only happen when the watch receives a jerk or shake, such as it would receive when being worn. To correct this it will be necessary to put in a larger escape wheel (if the fault is in the pallet depth) or a larger roller.

To make a watch go fast when the regulator is already over to the fast side the usual procedure is to

take up the balance spring at the stud. Remove the spring and collet from the balance, replace the spring stud, and ease the pin which holds the spring. Move a little of the spring through the stud hole and push the pin home. A movement equal to the width of the stud should represent an alteration of about five minutes a day. Replace the spring collet on the balance and screw down the balance.

A modern lever watch might have an irregular action, for example, gain fifteen minutes every twenty-four hours when hanging up, and lose slightly when put on its face. It is possible that in the hanging position there may be some obstruction to the free motion of the balance, such as a piece of bristle from the brush sticking under a screw head, or even on the plate or potance. Or the ruby pin may catch the corners of the lever notch when in the hanging position. Should any of these faults exist, they will show themselves readily. Watch the action of the balance when in the hanging position and see if it appears to strike anything and rebound. Listen to it, and some difference may be detected between hanging and lying. If no fault of this kind can be found, it may be that the balance is not properly poised, though to cause so large an error the fault must be a large one, such as a screw placed in the wrong hole in the rim. To test it, remove the hairspring and collet and place loosely in callipers or upon a parallel poising tool.

It is far commoner for a watch to lose when vertical and gain when horizontal, the cause being generally a want of perfect poise in the balance. To test it,

the balance must be taken out and the hairspring removed. Then the balance, with roller on, must be placed on a poising tool. If one point of the balance rim is heavy, that part will settle downwards; if in perfect poise, the balance will remain in any position in which it is placed. Gentle tapping of the base of the tool assists in discovering small errors. The heavy portion must be reduced by a little filing on the inner edge, if a plain balance; or, if a compensation balance, a screw at the heavy part must be reduced a trifle.

CHAPTER XIV

Watches Stopping: Causes and Remedies

Difficulty in Starting.—A lever watch in good order and perfectly "in beat" should start itself; even when there are slight imperfections, the least movement should be sufficient to start it. If the ruby pin in the roller is too large for the lever notch, or if it has a little shellac upon it, sticking may occur. The apparent sticking may result from the balance meeting with some resistance when the ruby pin enters the lever notch. A bent pallet pivot may cause the lever to move stiffly. If the banking pins in the plate are too wide apart, there will be great resistance to movement. To test for this fault draw the balance partly round to one side and see what "shake" the lever has against the banking pin. It should only have a little, just enough to ensure perfect freedom. Then try the other side in the same manner. Look also to the escape-wheel teeth to see if any are bent.

Stopping in Positions.—When a watch will go in one position and stop in another, the fault can generally be traced to a defective pivot or pivot hole; thus, if the watch be held so that the balance works on one pivot or in the pivot hole, and the watch stops, that pivot or hole is probably damaged. The pivot

may be bent, its end may be bruised and resemble a "mushroom," or it may be too short to come through the jewel hole and touch the endstone. The jewel hole or endstone may be cracked. Other causes may be too much endshake to the balance; the balance arms may touch the index curb pins or the hairspring stud; the balance rim may touch the balance cock or the watch plate, or (in a Geneva) the centre wheel; the hairspring may not be flat, and may touch the balance arms or the balance cock; the lever may touch the roller, or the escape wheel may touch the top or bottom of the slot in the cylinder.

The cause of a verge watch not going when lying on its back may be that the top verge pivot may be bent, the pivot hole may need bushing, the balance may foul the balance cock, or the hairspring may foul the balance. Hold the watch movement in the position in which it stops, and carefully observe all these things.

Occasionally a watch is found that will go in one position only—on its face, for example. This is often evidence of a fall which has cracked the cock jewel hole or endstone, or damaged the pivot. If, on examination, the pivot does not seem bent or damaged, see if its end comes well through the jewel hole. It may have worn short, and, if so, will require repolishing on the shoulder to let it through the hole a little farther. Failing anything wrong with the top pivot or jewel hole, look at the bottom pivot to see if it is flattened on the end like a mushroom; this sometimes causes the pivot to hang in the jewel hole.

See also that there is not an excess of oil between lever and top plate, that the lever does not touch the roller, that the hairspring is free, and the balance rim does not touch the index, the balance cock, or the cap.

Frequent Stopping.—When a watch frequently stops, sometimes twice a day, though a slight jerk is sufficient to start it again (the train wheels stopping suddenly, leaving the balance vibrating), there is a fault either in the wheel teeth or in the "depths," and, by the suddenness of the stoppage, it is most likely to be in the fourth or the escape wheels. First look for a bent or damaged tooth in the third or fourth wheel. Then see that there is not a little piece of grit (often transparent and difficult to see) wedged between two teeth or between two leaves of the fourth or escape pinions. Failing this, examine the "depth" of the third wheel with the fourth pinion, and that of the fourth wheel with the escape pinion. To try a depth, hold one arm of the fourth wheel firmly with tweezers, and with a needle point see if the third-wheel teeth have a little play between the pinion leaves. If tight, the watch will stop. Probably the fault is between the fourth wheel and escape pinion, and, if so, in cheap Geneva watches the escape cock is generally movable to a small extent, and can be pushed away from or nearer to the fourth wheel, and by this means the depth can be adjusted. Lack of lubrication has been known to cause sudden and frequent stopping.

Watch Stopping at Same Time Every Twelve Hours or Every Day.—When a lever watch stops at about the same time each day, there may be a fault in

the stopwork if it is a going-barrel watch, causing it to stick when run down to a certain point. Or in a fusee watch, the stop may stick sometimes, causing it to act too soon and stop the winding one or two turns short. A want of truth in the hour wheel or hour hand, causing binding in the dial hole, or a bent tooth in the motion work, may also cause the trouble.

Fusee Watch Stopping During Winding.—The stoppage is caused by the maintaining work failing to act, or to the watch not being perfectly "in beat." A lever watch that is properly in beat will start itself if brought to rest even if the maintaining work fails. The cause of failure of the maintaining work may be that the detent point is worn (see p. 43), and needs filing up sharp; or it may be because the detent point slips above the ratchet. If the latter, the point must be bent down with a pair of brass-nosed pliers. Other points to which special attention should be directed are the safety pin in the lever, which may be too far from the roller edge; the chain, which may bind against the top plate when fully wound, or may scrape against the inside of the cap or the back of the potance; the mainspring may not be quite free inside the barrel, or the hands may move too easily or touch the dial or glass.

Geneva Watch Stopping when Shaken.—Sometimes, when a Geneva watch has a poor balance action, a shake will stop it. The balance should vibrate one-third turn on either side of its position of rest, making a total vibration or "action" of two-thirds turn. A poor action may be caused by want of cleaning, or by something that prevents free motion of the balance,

such as bent pivots or a hairspring that is not quite flat and free. Failing these reasons, it may be that the mainspring is poor or not strong enough or bound in its barrel. Or there may be something in the train that absorbs the power, such as the centre wheel rubbing against the barrel. Again, if the watch is not properly " in beat," a shake may stop it. To ascertain if the watch is in beat, bring the balance to rest, and see whether an equal movement to right or left is sufficient to start it. The beat is regulated by turning the hairspring collet round on the balance until an equal movement in each direction will start the watch.

A lever watch will stop when shaken if the " safety action " is too shallow. To test this, hold the balance half a turn from its position of rest, and try the shake of the lever against its banking pin. Then try in the same way on the other side. If the safety pin in the lever is too far from the roller edge, the lever can nearly be made to pass the roller and it is not safe. In such a case, the safety pin must be bent forward a trifle, but not enough to cause the lever to bind against its banking pins. There must still be " banking shake " on each side.

Should a lever watch stop in the pocket only, the guard pin in the lever may be a little too far from the roller edge, and may jam against it when shaken; perhaps the trouble is assisted by a roughness on the roller edge; or the pallet depth is too shallow, and the escape teeth mis-lock.

Watch Going for Short Time Only.—The probable cause of a watch only running twelve hours after wind-

ing is that the mainspring has slipped off its hook in the barrel, or, if firm on its hook, may bind inside when half run down; or the watch may be in poor condition and stops as soon as the power decreases a little, or else the mainspring is a very bad one. If the watch is in bad condition it will have a very sluggish action even when wound to the top. The best course will be to take the barrel out and put a pair of sliding tongs on the winding square and wind the spring up, holding the barrel in the fingers. The spring should allow from four to five turns at least, and pull strongly and evenly. If it does not, take it out and see where the fault is. The spring may be an old, stiff one, and be badly cramped up, or it may be too wide (or high) for the barrel, and rub hard against the cover.

Should a mainspring be too long, the watch may stop hours before it ought to do so. If the barrel is very full, the spring has no room to wind up. The maximum number of turns is obtained when the space (area) occupied by the spring is equal to the unoccupied area. This condition is obtained by seeing that the spring occupies less than one-third of the inside diameter of the barrel. Also the stronger a spring is the thicker it is, and the fewer number of turns it will make.

CHAPTER XV

Demagnetising Watches

WHEN the cause of a stoppage or bad action cannot be discovered, it is easy to put it down to the watch being "magnetised." This is a comfortable conclusion to come to, but it is not often the case. A conclusive test is to place a small pocket compass, or "charm" compass, flat on the balance cock as the watch is going. If the compass needle remains fairly steady the watch is not magnetised. But if it flies backwards and forwards, trembles violently, and generally behaves in an extraordinary manner, magnetism is present.

A rough and ready way of demagnetising a watch is to tie a yard of string to the watch bow and twist it up. Then hold the watch suspended close to a powerful electro-magnet, such as a running dynamo. Allow the watch to spin round rapidly, roasting-jack fashion, and as it does so gradually withdraw it from the magnet until at a safe distance. But before treating a watch thus, it is as well to wedge the balance with tissue paper so that it cannot turn round, or damage to pallets, ruby pin, or pivots may result. It is safer to adopt a plan in which the watch remains still.

A variation of the above method is to hold the string vertically so that the watch is suspended at about a

yard from the magnet fields of a motor or dynamo and allowed to revolve, by virtue of the twisted string; at the same time it is oscillated like a pendulum towards and away from the motor, approaching at the nearest point to within about 3 in., but revolving all the time. This operation is repeated twice or three times on each pole of the motor.

A special demagnetising apparatus is illustrated in Fig. 72. It consists merely of an ordinary electro-magnet with the poles far enough apart to allow the article to be demagnetised to hang between them, as illustrated. For ordinary purposes it will suffice to make the iron core 5 in. long by $\frac{3}{4}$ in. in diameter, and attach inch pole-pieces to the ends 4 in. high and $1\frac{1}{2}$ in. by $\frac{1}{4}$ in. in section. The central bobbin is wound on a hard-wood shell, and consists of 2 lb. of No. 26 d.c.c. copper wire, the ends of which are brought out underneath the wooden base to a simple 2-pin plug and socket for connection by a length of electric light flexible to the nearest lampholder, the lamp being taken out of its socket and the plug inserted instead. The watch or other article which requires treatment is suspended by a twisted string over the poles of the magnet, not too close; and whilst rapidly rotating it is withdrawn in an upward direction slowly until at least 2 ft. above the magnet. The current is then switched off, and the cure ought to be complete.

The above particulars of winding would be suitable when using current from a lighting circuit at 110 volts. For use with four 2-volt accumulators connected in series to give current at 8 volts, the coil will need winding

with 1 lb. of No. 26 d.c.c. copper wire to suit the 8-volt battery, and instead of the flexible connection terminating in a plug for a lamp socket, it will be more convenient if it is finished off with two metal eyes or hooks for attachment to the accumulator terminals.

The simplest and safest method of demagnetising watches is as follows: Obtain a permanent magnet of the horseshoe form powerful enough to lift a dead

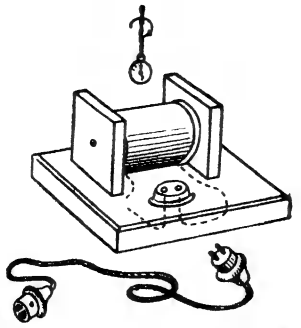

Fig. 72.—Watch Demagnetiser, for Attachment to Electric-light Main

weight of 10 lb. or 12 lb. Suspend this by a fine cord from any convenient hook in the ceiling, the poles hanging about $\frac{3}{4}$ in. to 1 in. above the top of a table. If the magnet be suspended with a pulley and counterweight it would be an improvement, as it could be raised and lowered at will without disturbing the rotation. Give the cord a strong twist so that the suspended magnet rotates rapidly, and place the watch movement underneath; allow it to remain for a few seconds, and then gradually withdraw the magnet to a distance of at least a couple of feet, after which the

watch should be completely demagnetised, and kept as far off as possible from the magnet thereafter. Note that the movement must be taken out of the case, or the effect will be merely to set up eddy currents in the case, and leave the exterior unaffected. Also be careful that the magnet is not approached so close as to distort the hairspring.

CHAPTER XVI

Some Miscellaneous Matters

Fitting Watch Bows.—The bows for key-wind cases are secured by a long thin screw passing through the bow ends and the case pendant. Bow screws can be purchased very cheaply at the material shops. New bows as bought have a screw ready fitted. An old watch is sometimes found to have a plain tapered pin instead of a bow-screw. In such a case the pin must be driven out with a punch to remove the bow.

Hardening and Tempering Springs.—All such watch parts are hardened by heating to redness and plunging into water or oil, then tempered to a full blue on a hot plate. Finally, they are cemented to a flat surface and polished to give the perfect surface seen in new watches. If it is desired to harden steel parts without impairing their surfaces, the parts must be heated without coming into contact with the air. This may be done by packing them tightly in a tube with carbon, heating all together, and when hot, shooting the contents into water.

Tightening Handwork.—In some watches the centre pinion is hollow, as already explained, and the set-hand arbor passes through the pinion, turning friction tight. In such a watch the arbor has become

too easy in the centre pinion and requires tightening. A watchmaker might do this by marking rings round the arbor, using for the purpose a pair of cutting nippers, or by holding the arbor in a pin-vice, and revolving it on a boxwood filing block, and pressing on it with the back edge of a graver. Or the arbor might be roughed a little by rolling it between two fine sharp files. In other watches the centre pinion and arbor are in one solid piece, and the cannon pinion turns on it friction-tight to set the hands. In this case, the cannon pinion will require tightening on the arbor. In order to do this, the arbor may be roughened as above described, or if the pinion has a snap (thin groove or hollow around it), the snap may be burnished in a little more or punched in with a steel punch, according to the kind of snap.

The hands of a Waterbury watch are driven from the barrel instead of the centre wheel in the ordinary way. Fixed friction-tight to the barrel boss is a wheel which drives the motor work, and this wheel is rubbed on just sufficiently tight enough to carry the hands. In the event of its appearing to be too loose to carry the hands, the safest plan is to rub round the rivet with a half-round burnisher.

Removing Tight Hands. — Ordinarily a pair of sharp cutting nippers inserted under the edge of the hand sockets and gently closed will bring the hands off, the jaws of the nippers acting as two wedges. When there is no room for cutting nippers, a pair of thin-edged cutting tweezers may be used. Occasionally an hour hand will resist all ordinary means of removal.

It is then wise to leave it attached to the hour wheel and dial. But if it must be removed for some special purpose, a pair of brass or ivory levers shaped like little curved crowbars may be used, one on each side and both together, to lift the hand from the dial.

Polishing Watch Wheels, etc. — The material generally used for polishing watchwork is known as "red stuff," and is obtainable at watch material shops. As a rule, parts are first smoothed with oilstone dust, which leaves them a fine grey; they are then polished with fine red stuff. Both the oilstone dust and the red stuff are used mixed into a paste with oil, and are applied to a "polisher" of a shape and a material suited to the work in hand.

To polish hardened and tempered steel, a polisher of soft steel is used; to polish brass, a polisher of pewter or willow wood. The round axis of a pinion, a balance staff or a pivot, is polished as it runs in the lathe. A polisher made from a strip of steel $\frac{1}{8}$ in. wide and 6 in. long is filed flat on one side and one edge, a slight "grain" being left on it by means of a fine file. The polishing paste is mixed on a flat steel "stake" having a dust-tight cover. A little paste is rubbed into the polisher, and a backward and forward motion given, as if the work were being filed as it runs in the lathe. At each fresh application of the polishing paste the polisher is re-filed clean. A flat piece like an index is cemented to the bed of a "swing polishing tool" to ensure keeping it flat.

A brass wheel can be laid on clean cork, and polished with a long willow or boxwood polisher. A

small brass wheel can be rubbed over a polishing block of pewter filed flat. Polishing requires much practice.

A large surface such as the cap that screws on the winding ratchet of a keyless Geneva is difficult to polish, and considerable practice will be required to do the work. A solid block of bell metal, flatted and stoned smooth on one side, will be necessary. This is covered with a thin paste of fine red stuff or diamantine and oil. The piece to be polished is rubbed across and across and round and round on the polishing block. A peg inserted into the central hole serves to operate it. These surfaces are never burnished. A clean grey will look better than a bad polish, and can be gained by rubbing the steel piece on a piece of fine ground glass with oilstone dust and oil. This is a much easier process.

The circular part of the index of an oversprung lever watch is polished by rubbing in circular strokes on a flat surface block, the index itself being cemented with shellac to a small brass block. To flat it, use a small piece of plate glass for a block, and oilstone dust and oil as a cutting medium. To polish, use a bell-metal block, and fine red stuff and oil as a medium. The index finger portion is polished by resting on a boxwood block and using a long, flat steel polisher overhand, as in polishing pivots.

An undersprung index must be cemented to a bed-plate of brass arranged as a swing tool, with a centre at each edge, so that it can be placed in the turns. A long bell-metal polisher is used overhand; the plate

rocking upon the turn centres ensures the polisher keeping the index flat.

Frosting Plates, etc. — Watch plates are frosted by the sand-blast process to give them a granular surface, the process being carried out previous to gilding. Or they can be washed for a few minutes in a weak solution of caustic potash, rinsed in cold water, then immersed for an instant only in a strong bath of nitrous acid (not diluted), and immediately washed in water. The acid treatment does not always attack the brass evenly all over, and is not so good as the sand-blast.

Preparing Plates for Gilding. — After being rubbed smooth with water-of-ayr stone, the plates are immersed for a second or two in a mixture of 4 parts of hydrochloric acid and 5 parts of nitric acid, both at full strength. They are then thoroughly rinsed and scratch-brushed, after which they are ready for gilding. Sometimes the plates are heated before dipping them in the gold solution; this softens them but enables a good colour to be got with but very little gold.

Fitting Glasses.—Glasses are fitted by snapping them into the groove in the watch bezel by pressure of the fingers only. First clean out the groove with a pointed watch peg, and press out any bruises with a small screwdriver blade. Then open the bezel and snap in the glass. Glasses cannot be fitted with the bezel shut. To take a glass out, push it from the back. The knack of fitting watch glasses takes a considerable time to learn, and is the result of constant

practice. Beginners always break several glasses. A watch cannot be measured for a glass; glasses have to be fitted by trial until one is found that snaps in tight. A watch-glass gauge can be bought from the tool and material dealers.

Glasses that are a little too large can be edged in by means of a fine emery buff applied by hand. Of course, a glass can be reduced in size only by a very small amount. Emery buffs consist of emery paper glued on wood. The reduction can be done by holding the glass in the hand and going round and round with a No. 1 buff for a few minutes, applying the buff to the edge of the glass to round off the extreme sharpness only, then smoothing up with a No. 2/0 or 3/0. Or the glass can be mounted in the turns or watch lathe, and revolved while a buff is held to its edge, special arbors, fitted with discs of cork, being used to hold the glass.

The makers edge the glasses on a vertical lathe with emery powder and water on grinding tools of iron, afterwards polishing with rouge on wood or pitch.

Filling Up Key-hole in Case.—An unused key-hole in a silver case may be filled up by cutting a piece of sheet silver to fit it exactly and silver-soldering it in. Silver solder is used, and a paste of borax and water serves as a flux. When well done, smoothed up and polished, the hole will be invisible. The new key-hole is then made where required by first drilling a small hole, then drawing and opening it to size with a rat-tail file. Before soldering, the steel work must all be removed from the case and the joints unpinned.

Changing Dial.—It may be required to replace a

gold dial with, say, a white-enamelled copper one. The usual course is to drill new holes in the watch-plate to correspond with the dial feet. Make a scratch on the edge of the plate opposite the twelve with the old dial on. Press the feet of the new dial through a piece of paper, and cut it round flush with the dial. Then make a mark on the edge of the paper opposite the twelve. Remove the paper, place it on the watch plate with the twelve mark opposite the scratch, mark round the holes in the paper, and drill them through the plate.

On no account remove the copper studs or dial feet from the white dial. These feet are soldered to the copper plate before it is enamelled, and it would therefore be impracticable to fix them in another place without removing the enamel, and the enamel would crack in the process. In the case of a metal dial, drill the new feet holes in the watch plate at the required positions. Fix the dial on, and mark it through the new holes with a drill the same size. Select a piece of copper wire the same size as the new holes. File the end flat and soft-solder it to the mark on the dial. A piece of copper wire, not less than 3 in. or 4 in. long, will be found easiest to hold upright in soldering. Cut off the foot to length, and fix the other in the same manner.

Removing Name from Enamelled Dial.—If the name is simply painted on, a little spirit of wine will soon remove it. If the name is burnt in, it must be ground out. The best cutting medium is diamantine powder, which can be obtained from watch material

shops. To use it, mix into a paste with oil and apply with a watch peg cut flat on the end. Rub with straight strokes across in every direction, alternating with irregular circular strokes. It will probably take one hour's patient rubbing to remove the last traces of the name.

Using Watch Screw-plate.—When using a watch screw-plate, lubricate it freely with oil. To ensure good lubrication, screw the wire in half a turn, then back a quarter, in another half a turn, and so on. If this is done, the threads will be cut clean. It is, perhaps, best to use the plate with the numbered side uppermost. The two rows of holes are exactly alike in size. If one hole becomes choked with brass, drill it out and insert a suitable tap to clear the thread.

Making Taps for Watch Screw Threads.—Taps for watch screw threads could be made from needles, but probably they would not last long. A tap should be made from the best steel; therefore get a length of tool steel wire of the correct size. From this cut off a suitable length, say 1½ in. Soften it by heating to a dull red and allowing it to cool slowly. Hold it in a pin-vice and, resting it on a piece of boxwood, file it to a gentle taper until the end just enters the hole in a screw-plate; the wire may then be screwed into the latter, plenty of oil being used. When it goes hard, turn it back half a turn, then forward three-quarters of a turn, back half a turn again, and so on, advancing slowly until a full thread is cut for a sufficient distance. Then file three flats upon it for the whole length of the thread, tapering the flats to the end, where they

should meet in a knife edge and show only half a full thread. Harden the tap by heating to a red colour and plunging in cold water. Brighten one flat and heat it over a flame until it is of a pale straw colour. This renders it less brittle, and is called "tempering." Then carefully smooth all three flats on an oilstone so as to leave good cutting edges. Finally, file some nicks in the soft end to indicate the number of the hole in the screw-plate to which it belongs.

Blueing Screws.—Watch screws are blued by heat. First polish the top of the head, then take a strip of thin sheet brass in which are a few holes of assorted sizes. Place the screw standing up in one of the holes, with the head resting on the brass. Then slowly heat it over a spirit lamp flame. The polished surface first turns a straw colour, then red, then dark blue. Immediately this appears, tip off the screw.

Removing Broken Screw from Watch Plate.—Tools are sold for the purpose of removing broken screws from watch plates, but they seem to be of little or no use. If the screw projects a little, slit it with a slitting file and screw it out. If it is not very tight and is broken low down in the hole, try two sharp graver points on opposite sides, held one in each hand, to turn it out. If the screw is tight and not hard, drill it right through and broach it out. If hard, make a hard punch to fit the hole and have a flat end to rest on the screw. Rest the plate on a steel stake over a hole and, with a heavy and sharp blow with a hammer, punch the screw right out. This will strip the thread from the hole and necessitate re-tapping.

A broken screw in a watch plate, not projecting on either side, may sometimes be removed by putting the plate in a lathe between two points slightly blunt. Apply strong pressure on one of the points to keep the screw steady, and turn the plate.

Screw-extracting tools work on the principle just described. Fig. 73 is a simple pattern. It consists of a cramp, large enough to reach across a watch plate. Provide two or three sets of $\frac{3}{32}$-in. steel screws with different-size hardened chisel-like points. To

Fig. 73.—Device for Removing Broken Screws

use the tool, tighten the chisel point against the broken screw, and when there is a firm grip turn the whole tool round.

Mechanism of Minute Repeating Watch.—A minute repeating watch contains two circular steel wire gongs around the movement edge. These are struck by two hammers. The hours are sounded on the first gong, the quarters being struck "ting-tang" on both gongs; the minutes are struck on the second gong. The hammers are operated by saw-toothed racks like clock striking racks, the teeth operating on small pallets on the axes of the hammers. The motive

force is a mainspring which is wound up by the forcing along of a slide in the case edge each time the watch is required to repeat.

A train of wheels and a " fly " regulate the speed of striking. There is an "hour" snail with twelve steps to determine the number of strokes at each hour. This is moved each hour, as in a clock, and limits the fall of the hour rack. The quarter rack has a double set of teeth to operate alternately on both hammers. It is limited in its fall by the quarter snail, having four steps, and turning once per hour with the minute hand. The minute rack has fourteen teeth, and falls upon the minute snail, which has four segments, each divided into fifteen steps, and turns once per hour with the quarter snail. When the case slide is pushed home, the repeating spring is wound up, the three racks fall as far as their snails allow them, and the repeating train begins to run. The hour rack is first carried forward, and its teeth cause the hour to be struck; then the quarter rack, and finally the minute rack.

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